ESSO TUTU SERVICE STATION
St. Thomas, U.S.Virgin Islands

SOIL VAPOR EXTRACTION, BIOVENTING, & GROUND-WATER TREATMENT SYSTEM

FINAL REMEDIAL DESIGN REPORT

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SECTION 1.0

INTRODUCTION

Pursuant to Section III of the Statement of Work (Appendix II) attached to the Unilateral Administrative Order (UAO) dated May 1998, this document is being submitted to fulfill the requirement to prepare a Final Design Report for Remedial Work Element I - Soil Remediation and Remedial Work Element II - Ground-Water Remediation.

The Tutu area of Saint Thomas has been the focus of an ongoing Environmental Protection Agency (EPA) directed investigation subsequent to July 1987. EPA's investigative activities were precipitated as a result of the detection of volatile organic compounds (VOCs) in several potable wells located within the northern portion of the Tutu aquifer basin. Specifically, sampling conducted by Roy F. Weston in July 1987, on behalf of EPA, identified the presence of synthetic chlorinated organic compounds and aromatic hydrocarbons at variable concentrations and in sporadic locations within a number of ground-water production wells in the Tutu area. Subsequent to July 1987, periodic water quality sampling of potable wells has been conducted by EPA. Additional site inspections, document reviews, and sampling activities have been implemented in an attempt to identify potentially responsible parties (PRPs).

In 1992 EPA directed the Tutu Environmental Investigation Committee (TEIC), comprised of Texaco Caribbean, Inc. and Esso Standard Oil, to implement a joint hydrogeologic investigation within the Tutu area. In an attempt to characterize the extent and sources of ground-water contamination, monitoring wells were installed, soil/ground-water samples were collected, and aquifer hydraulic information obtained. Findings from this investigation were presented by Geraghty & Miller in a Technical Memorandum (Tech Memo II) dated May 1993. This investigation program represented the first step in the iterative process through which a comprehensive Remedial Investigation/Feasibility study (RI/FS) for the Tutu area was developed.

To address data gaps identified in the Tech Memo II, Geraghty and Miller developed a Phase II RI program in 1993. This program was submitted to EPA in December 1993, and subsequently approved and implemented in 1994. Findings of the Phase II RI were presented in a Phase II RI Report dated April 1995.

In addition to the valley-wide RI activities conducted by EPA and TEIC, several PRPs have conducted site-specific investigations. Specifically, Esso commissioned several site investigations of the Tutu service station which were implemented in a phased-approach and included the following significant tasks:

- assessment of soil quality proximal to former gasoline storage tanks;
- determination of environmental conditions adjacent to potential on-site source areas including the gasoline dispenser island, former location of hydraulic lifts, oil/water separators, and existing gasoline storage tank field;
- characterization of hydrogeologic conditions beneath and adjacent to the site; and
- determination of ground-water quality on site, as well as upgradient and downgradient of the service station.

EPA issued a Record of Decision (ROD) dated August 5, 1996 which set forth EPA's selected remedy. The major components of the selected remedy as it relates to the Esso service station include the following two Remedial Work Elements:

<u>Remedial Work Element I - Soil Remediation</u>

- Institutional controls to place limitations on property usage;
- Institutional controls to ensure excavation or disturbance of soils will not occur without permit approval, proper worker-protection precautions, and monitoring for fugitive emissions;

- Institutional controls to prohibit excavation, transportation, and use of soil or rock from impacted areas with EPA and DPNR approval;
- Soil Vapor Extraction (SVE) treatment and bioventing of impacted soil; and
- Thermal oxidation for off-gas treatment.

Remedial Work Element II - Ground-Water Remediation

Implement Source Control Program (SCP) including the installation and operation of extraction wells and an air stripper to address impacted ground water.

In accordance with the ROD, a Remedial Design Investigation was implemented to:

- Delineate the extent of impact to vadose zone soils adjacent to the north oil/water separator and dispenser island;
- Define the extent of the perched water zone and the phase-separated hydrocarbons in the vicinity of the north oil/water separator;
- Quantify site-specific vadose zone characteristics to establish soil cleanup criteria; and
- Collect requisite data to design a soil vapor extraction and ground-water collection remediation system.

Field investigation activities were performed during the period from September 16, 1996 to October 16, 1996. Based upon the investigative information collected during the Remedial Design Investigation, a Source Control Program was developed. The objectives of the Source Control Program are as follows:

- Remove phase-separated hydrocarbons present in the perched water zone on site and the shallow portion of the bedrock aquifer both on site and off site;
- Remediate vadose zone soils to ensure potential leaching of contaminants from unsaturated soil to the water table does not result in ground-water concentrations above Federal Maximum Contaminant Levels (MCLs); and
- Hydraulically capture and remediate volatile aromatic hydrocarbon plume present in the overburden and shallow bedrock.

The investigation findings and a conceptual design for the components of the Source Control Program were presented in the Remedial Design Investigation/Source Control Program Report (FES, 1997). The remedial system will involve the following:

- Soil vapor extraction (SVE) and bioventing of vadose zone soils;
- Removal of phase-separated hydrocarbons using both fluid extraction and vapor extraction/bioventing; and
- Ground-water recovery and treatment with an air stripper.

This document is being submitted in fulfillment of the requirement for submission of the Final Design Report for Remedial Work Elements I and II. The report is organized as discussed below, along with supporting appendices. Section 2 summarizes the site environmental setting data and background information relative to the extent of soil and ground-water contamination. Section 3 describes the objectives and design criteria, Section 4 presents the basis of design, and Section 5 discusses remedial system components and associated contingencies for Remedial Work Elements I and II. Section 6 outlines performance criteria and performance contingency measures. Institutional controls, permits, and access agreements for the site are described in Sections 7, 8, and 9, respectively. Section 10 is the Construction Quality Assurance Project Plan (CQAPP). Accompanying appendices include: Calculations, Previous Investigative/Pilot Testing Results, and Miscellaneous Basis of Design Information (Appendix A), Site Permits (Appendix B), and the Access Agreement (Appendix C). Separately bound documents which accompany this report include: the Project Manual (which includes Technical Specifications), the Technical Drawings package, and the Operations and Maintenance (O&M) Manual which includes the Sampling and Monitoring Plan (SAMP) and the Post-Remediation Monitoring Plan.

SECTION 2.0

SUMMARY OF SITE ENVIRONMENTAL CONDITIONS

2.1 Site Geology and Hydrogeology

The geologic sequence at the Esso Tutu Service Station consists of fill and unconsolidated Quaternary sediments overlying volcanic bedrock. The fill material varies in thickness from 2 to 3 feet at the northern property boundary to approximately 10 to 15 feet in the southwestern portion of the site. In general, the fill consists of a fine sand/silt/clay matrix surrounding angular rock fragments. In certain areas, such as the southwestern corner of the site, the fill material also includes cobbles and construction debris. Beneath the fill are unconsolidated alluvial and colluvial deposits and weathered bedrock. These sediments range in thickness from 2 feet in the northern portion of the site to approximately 5 to 6 feet in the southwestern corner of the property. These deposits can best be characterized as a poorly sorted mixture of clay, silt, sand, gravel and cobbles. Weathered bedrock (saprolite) at the site is composed of dense silt and clay, extending from depths ranging from 4 feet to 20 feet below the ground surface.

Bedrock in the vicinity of the Esso Tutu Service Station consists of two volcanic formations: the Water Island Formation and the Louisenhoj Formation. The Water Island Formation is composed primarily of basaltic flows and breccias. It is unconformably overlain by the Louisenhoj Formation which consists of pyroclastic to epiblastic, augite-andesite tuffs and breccias. Locally, the base of the Louisenhoj Formation consists of the Cabes Point Conglomerate, which contains well-rounded and well-sorted pebbles and cobbles of the older Water Island Formation (Donnelly 1959 and 1966). The depth to competent bedrock varies from 5 feet along the northern property boundary to 20 feet in the southwestern portion of the site.

Ground water at the Esso Tutu Service Station is present in two separate units: a shallow perched water zone and the regional water table aquifer. A localized perched ground-water zone is present in the southwestern portion of the station property, proximal to the north oil/water separator (Figure 2-1). Perched ground-water conditions are manifested as a result of a permeability gradient between fill deposits and saprolitic strata. The increased clay content and limited permeability of the saprolite inhibits vertical transport through the vadose zone. Perched water conditions were not encountered during soil boring advancement north of the north oil/water separator or in the area of the dispenser island/underground storage tanks (USTs). Similarly, perched water conditions were not encountered at monitoring well SW-8 or the MW-9 cluster, effectively defining the spatial extent of the perched ground water beneath the site. Depth to water in the perched zone is approximately 9 feet to 10 feet below grade.

Considering both the limited spatial extent of the perched water zone and the site lithology, horizontal ground-water migration in this unit is thought to be minimal. Ground-water elevation data suggest that there is little, if any, hydraulic interaction with the underlying water table aquifer. Information collected during ground-water pumping tests, as well as ground-water monitoring events, demonstrate that water levels in the two units fluctuate independently. Historically, ground-water elevations in the perched zone have been consistently 8 feet to 10 feet higher in elevation than water levels in the water table aquifer as demonstrated by comparing hydrographs for SW-7 (located in the perched zone) with hydrographs for SW-2 and SW-8 (located outside the perched zone). Hydrographs are included in Appendix A.

The source of hydraulic recharge, if any, to the perched zone has not been specifically identified. The presence of pavement and above ground structures both on and proximal to the site, reduce the potential for surface water/precipitation infiltration. Observations recorded during the completion of soil borings and trenches north of the oil/water separator and/or dispenser island demonstrated the absence of moisture in subsurface deposits, despite the termination of borings/trenches upon the bedrock surface. One potential recharge source may be the cistern located beneath the station building. The cistern had received water from the roof drainage system prior to the impact of Hurricane Marilyn in Fall 1995. Subsequently, the cistern has been replenished with shipments of water delivered once or twice per week (water from the cistern is presently used in the station rest rooms).

Ground water associated with the water table aquifer is present at depths of 17 to 20 feet beneath the site. Although chemical properties of the water table aquifer vary with depth, shallow and deep portions of the aquifer are believed to comprise a single hydrogeologic unit. Regional ground-water flow beneath the site is generally north to south, under an approximate hydraulic gradient of 0.03 (Figure 2-2). Vertical ground-water elevation measurements suggest a slight downward gradient ranging from 0.0035 to 0.01.

Aquifer characteristics have been quantified through a series of single-well hydraulic conductivity tests (i.e., slug tests) and short term constant rate pumping tests. Single-well hydraulic conductivity tests indicate that the permeability of the shallow fractured bedrock beneath the Esso Tutu Service Station ranges from 4.61×10^{-6} ft/min to 1.55×10^{-4} ft/min. The calculated hydraulic conductivity value for the deeper portion of the fractured bedrock (well location DW-1) was 1.01×10^{-5} ft/min. The low permeability of the shallow fractured bedrock is demonstrative of the limited fracture density proximal to the service station site. Ground-water pumping tests, conducted at a rate of 0.5 gpm in wells SW-1, SW-3, SW-7 and CHT-2, demonstrated hydraulic conductivity values ranging from 4.0×10^{-6} ft/min to 1.3×10^{-3} ft/min. Most calculated hydraulic conductivities were within the range of 10^{-4} ft/min to 10^{-5} ft/min.

Hydraulic conductivity data for the aquifer pumping tests, in conjunction with ground-water gradient information, indicate that ground-water velocity in the area of the Esso Tutu

Service Station is relatively slow. Employing the geometric mean of the hydraulic conductivity data (0.0001 ft/min) for the shallow aquifer monitoring wells, and assuming an effective porosity of 0.15 for the shallow bedrock zone, produces a calculated ground-water velocity of approximately 10.5 feet per year. Pumping test results and hydraulic conductivity calculations are discussed in greater detail in Section 4.2.1.

2.2 Contaminants of Concern

As defined in the August 5, 1996 Record of Decision (ROD), specific contaminants of concern for the entire Tutu Wells NPL Site include volatile aromatic hydrocarbons such as benzene, toluene, ethylbenzene, xylenes (BTEX) and chlorinated volatile organic compounds (CVOCs) including tetrachloroethene, trichloroethene, dichloroethene, and vinyl chloride.

2.3 Extent of Soil Impact (Remedial Work Element I)

Two areas within the unconsolidated vadose zone soils at the Esso Tutu Service Station have been identified as being impacted: 1) the area surrounding and downgradient (i.e., south) of the north oil/water separator; and, 2) the former dispenser island and product distribution lines.

2.3.1 North Oil/Water Separator

Soil quality proximal to the north oil/water separator was defined during previous sampling programs implemented in 1993 and 1996. Samples SS-1, SS-3, SS-4, SS-5, SS-6, SS-7, and SS-8 were collected on the western side of the separator following excavation and removal of the effluent pipe in 1993 (Figure 2-3). Ten soil borings were drilled proximal to the north oil/water separator in 1996 to: 1) delineate the extent of impact north of the separator; and 2) characterize the contaminant levels associated with the perched water conditions south of the separator (proximal to well SW-7). Borings B-16 and B-17 were installed north of the separator and borings B-1, B-2, B-5, B-6, B-7, B-15, B-18, B-19, and B-20 were drilled south of the separator (Figure 2-4).

Analytical data from these sampling events detected the presence of aromatic hydrocarbons (e.g., BTEX), polynuclear aromatic hydrocarbons (PAHs), and to a lesser extent CVOCs. CVOCs were detected only in soil samples collected from a test pit to the west of the separator in 1993. No CVOCs were detected in soil boring samples collected in 1996. CVOCs are limited to the shallow soils adjacent to the north oil/water separator; they were not widespread in the perched water zone. The following discussion summarizes the conclusions regarding the distribution of these different compounds presented in the Remedial Design Investigation/Source Control Program Report (FES, 1997).

Aromatic hydrocarbon compounds, present in the vicinity of the north oil/water separator and the alleyway to the south of the separator, were detected at the highest concentrations in soil samples SS-1 (9 feet), SS-3 (3 feet), SS-7 (5 feet) and SS-8 (7 feet), all collected from a test pit located immediately west of the separator (Table 2-1). Highest detected compound concentrations included toluene, ethylbenzene, and xylenes, with a maximum reported total BTEX concentration of 142.3 milligrams per kilogram (mg/kg). Samples SS-4 and SS-5, collected about 8 feet west of the separator, contained total BTEX levels of 29.8 mg/kg and 36.0 mg/kg, respectively. Aromatic hydrocarbons were not detected in Sample SS-6, located about 12 feet west of the separator and adjacent to the western property boundary, effectively delineating the western extent of aromatic impact. Samples collected from south of the separator (B-5, B-6, B-7, B-15, and B-20) demonstrated low concentrations of total aromatic hydrocarbons (less than 1 mg/kg), delineating the southern extent of soil impact (Table 2-2). Borings B-16 and B-17 effectively delineate the extent of aromatic compounds north of the separator.

CVOCs were observed in the soil samples collected from the test pit immediately to the west of the north oil/water separator, except for sample SS-6. Compounds detected including 1,2-dichloroethene (1,2 DCE), trichloroethene (TCE), tetrachloroethene (PCE), and 1,1,1-trichloroethane (1,1,1-TCA). Samples SS-3, SS-7, and SS-8 exhibited the highest CVOC concentrations with total CVOC concentrations of 5.12 mg/kg, 0.67 mg/kg, and 2.19 mg/kg, respectively (Table 2-2). Individual compounds observed at the highest concentrations included 1,2 DCE (3.2 mg/kg, sample SS-3) and PCE (1.5 mg/kg, sample SS-8). CVOCs organic compounds were not detected in any of the 25 samples analyzed during the 1996 RD Investigation.

The presence and distribution of PAH compounds mimicked that of the aromatic compounds. In general, the highest levels were reported adjacent to the north oil/water separator at depths of 3 to 7 feet (samples SS-3, SS-7, and SS-8). Individual constituents detected at the highest concentrations included naphthalene, phenanthrene, and pyrene. Sample SS-6 collected along the western property boundary demonstrated non-detectable levels of all PAHs. Although PAH compounds were observed in soil samples collected in the alleyway south of the separator as well as north of the separator in sample B-16 (Table 2-2), the reported concentrations were less than those observed adjacent to the separator.

In summary, field observations during the drilling of borings south of the north oil/water separator demonstrated the highest concentrations of aromatic hydrocarbon and PAH compounds in the 8 to 10 foot and 10 to 12 foot sample intervals. These sample intervals correlate with the elevation of the perched water zone, and as such, contamination in this area has resulted from horizontal transport of hydrocarbons on the perched water.

2.3.2 Dispenser Island and Product Distribution Lines

Soil quality adjacent to the former dispenser island and product distribution lines has been defined through previous sampling and investigative programs implemented in 1993, 1995, and 1996. Soil borings SW-1, SW-2, and SW-3 (Figure 2-4) were drilled and sampled in 1993. Ten soil borings were drilled in 1996; borings B-3, B-4, B-8, B-9, and B-10 were located adjacent to the former dispenser island, while borings B-11, B-12, B-13, B-14, and B-24 were located further west and adjacent to the service station building.

Analytical data obtained during these investigations demonstrated the sporadic presence of BTEX and PAHs compounds. CVOCs were not detected in any samples collected adjacent to the dispenser island and product delivery lines. The following discussion summarizes the conclusions regarding the distribution of these compounds presented in the Remedial Design Investigation/Source Control Program Report (FES, 1997).

Aromatic hydrocarbon compounds were detected in samples collected from boring B-3 drilled adjacent to the former pump island, as well as borings B-11 and B-13, completed adjacent to the service station building. The maximum total BTEX concentrations in these three borings were 1.1 mg/kg, 0.002 mg/kg, and 0.15 mg/kg, respectively. The depth of impact in these borings was typically shallow (4 to 8 feet). BTEX compounds were either not detected or reported at low estimated concentrations in the remaining borings installed adjacent to the former pump island. The highest BTEX concentrations were observed in samples B-14 (47.2 mg/kg, 10 to 12 feet) and B-24 (236.7 mg/kg, 9 to 11 feet), but samples collected at shallower depths in these same borings demonstrated low to non-detectable levels of BTEX compounds. Field observations and the above analytical results suggest that the contamination associated with the perched water zone encountered during investigation of the north oil/water separator extends as far eastward as boring B-24 (Figure 2-1).

Samples from borings B-3, B-4, B-14, and B-24 were submitted for PAH analysis. Analytical results for samples from borings B-3 and B-4 were reported at an elevated method detection limit, generally less than 0.1 mg/kg. The distribution of PAH compounds in borings B-14 and B-24 mimics that of the aromatic compounds.

2.4 Extent of Ground-Water Impact (Remedial Work Element II)

Ground-water quality data indicate the presence of two distinct contaminant plumes beneath the subject property: 1) a volatile aromatic hydrocarbon and dissolved PAH plume emanating from the north oil/water separator, and 2) a volatile aromatic hydrocarbon plume originating from the dispenser island/distribution line area. The aromatic hydrocarbon plume originating from the dispenser island area has impacted ground-water quality in the shallow bedrock aquifer. Impact associated with the north oil/water separator is principally limited to the perched ground-water zone. Phase-separated hydrocarbons have been associated with each of the plumes. Although CVOCs were detected in a limited area of shallow soils (e.g., 3 to 7 feet deep) adjacent to western edge of the north oil/water separator, CVOCs have not been detected in water or phase-separated hydrocarbons associated with the perched water zone. CVOCs are present in upgradient well MW-8 and are considered indicative of the regional impact to the Tutu Aquifer from upgradient sources.

2.4.1 North Oil/Water Separator

Data characterizing ground-water quality in the perched water zone and downgradient of the north oil/water separator has been obtained from monitoring well SW-7 (Figure 2-4). Ground-water elevation data for well SW-7 indicates this well is screened within the perched water zone and hydraulically separated from the water table aquifer. As depicted in Figure 2-1, the spatial extent of the perched zone is limited. The perched zone was not encountered during the drilling of wells SW-3, SW-8, or CHT-2.

Ground-water quality monitoring at well SW-7 over a 2.5 year period demonstrated concentrations of individual BTEX analytes ranging from a minimum of 16 micrograms per liter (µg/L) of toluene to a maximum of 171 µg/L of total xylenes (Table 2-3). Two sampling events in 1994 demonstrated benzene concentrations of 99 µg/L and 160 µg/L.

Certain PAH compounds have also been observed in ground-water samples collected from well SW-7, including naphthalene, fluorene, and phenanthrene. Individual concentrations of PAH compounds have ranged from not detected to 96 µg/L (naphthalene). Chlorinated volatile organic compounds have never been detected in ground-water samples from well SW-7. The detection of PAH and aromatic compounds in well SW-7 is indicative of a release from the north oil/water separator and consistent with the compounds observed in soil samples collected following removal of the effluent pipe from the separator.

2.4.2 Dispenser Island and Product Distribution Lines

Monitoring wells characterizing ground-water quality proximal to the dispenser island, distribution lines, and USTs include SW-1, SW-2, SW-3, and CHT-3 (Figure 2-4). Monitoring wells MW-8, SW-8, CHT-7D, MW-10, and MW-10D are instrumental in defining the spatial extent of the aromatic hydrocarbon plume emanating from the gasoline storage and dispensing area.

Ground-water quality data from wells SW-1, SW-2, and SW-3 have consistently demonstrated the presence of aromatic compounds. The highest reported concentrations were observed at wells SW-1 and SW-3, with total BTEX concentrations ranging from approximately 55 milligrams per liter (mg/L) to 135 mg/L, respectively. Phase-separated gasoline was detected in well SW-3 during the 1996 sampling program. Although BTEX constituents were detected in SW-2, reported concentrations were significantly less than those observed in SW-1 and SW-3. During the September 1996 sampling event, individual BTEX compounds at SW-2 ranged from a minimum of 18 μg/L (ethylbenzene) to a maximum of 220 μg/L (benzene). Data from well SW-2 during the 1994 sampling events demonstrated slightly higher concentrations; however, total BTEX levels were still less than 8 mg/L.

Aromatic hydrocarbon compounds (i.e., BTEX analytes) have consistently been detected in well CHT-3, located approximately 20 feet downgradient of the USTs. Data from 1994 indicated total BTEX concentrations of approximately 4.5 mg/L, while observations recorded in 1996 indicated the presence of phase-separated gasoline. Monitoring well MW-10, located approximately 50 feet downgradient of the USTs demonstrated the presence of benzene (2 μg/L, estimated concentration) and ethylbenzene (5 μg/L) during the September 1996 sampling event. Data collected in 1994 from MW-10 demonstrated the absence of all aromatic hydrocarbon compounds. Information from MW-10 has been used to define the downgradient extent of volatile aromatic impact from the gasoline storage and distribution system. Monitoring well MW-8, located upgradient of the dispenser island and adjacent to the northern boundary of the site, has consistently demonstrated the absence of volatile aromatic hydrocarbon compounds. However, as mentioned previously, CVOCs were detected in this upgradient well and are considered indicative of the regional impact to the Tutu Aquifer from upgradient sources.

2.4.3 Regional Ground-Water Quality

Ground-water analytical data have consistently demonstrated the absence or near absence of CVOCs in monitoring wells located immediately downgradient of the USTs and dispenser island. Specifically, chlorinated compounds were not detected in wells SW-1 and SW-

3 during the 2.5 year sampling program. Monitoring well SW-2, located along the eastern edge of the station property, exhibited a maximum individual chlorinated compound concentration of 32 µg/L (1,2 DCE).

Data from on-site monitoring well SW-8, as well as monitoring points CHT-2 and the MW-9 well cluster, have consistently demonstrated the absence of significant concentrations of CVOCs in the water table aquifer. Monitoring wells SW-8, CHT-2, and the MW-9 cluster are located 40 to 60 feet downgradient of the north oil/water separator.

Monitoring wells MW-10 and MW-10D, located approximately 50 feet downgradient of the Esso Tutu Service Station, each demonstrated detectable concentrations of certain CVOCs. Reported concentrations at these locations are consistent with those observed in well MW-8 located at the northern (i.e., upgradient) property boundary of the service station, as well as further north of the service station. They are indicative of the regional impact of the Tutu Aquifer (northern CVOC plume emanating from the former LAGA facility). The maximum individual CVOC concentration detected in this well cluster was 110 µg/L (1,2 DCE).

2.4.4 Distribution of Phase-Separated Hydrocarbons

Phase-separated hydrocarbons have been detected in two areas of the site: 1) proximal to the USTs and dispenser island; and, 2) proximal to the north oil/water separator. Phase-separated hydrocarbons present proximal to the USTs and dispenser island have been identified in monitoring wells SW-3 and CHT-3. Based upon historical well gauging data, monitoring wells SW-3 and CHT-3 have only recently exhibited the presence of phase-separated hydrocarbons. Information collected in 1993 and 1994 demonstrated the absence of free phase hydrocarbons in both wells. However, data collected in 1996 demonstrated the presence of phase-separated hydrocarbons in both SW-3 and CHT-3, with an apparent product thickness ranging from 0.01 feet to 0.40 feet (Table 2–4). The phase-separated hydrocarbons present in these two wells are similar and exhibit chemical characteristics of weathered gasoline. Monitoring well SW-2, located along the eastern edge of the site has never demonstrated the presence of phase-separated hydrocarbons. In addition, monitoring well SW-1, located between wells SW-3 and CHT-3, and immediately downgradient of the USTs, has also never demonstrated the presence of phase-separated hydrocarbons.

Phase-separated hydrocarbons have consistently been observed in well SW-7 (perched water zone), located downgradient of the north oil/water separator. Measurements collected in 1996 demonstrated an apparent product thickness ranging from 0.01 to 0.34 feet. Based upon laboratory analytical data, as well as field observations, phase-separated hydrocarbons present at SW-7 are distinctly different than those observed at monitoring wells SW-3 and CHT-3. The product sample obtained from well SW-7 was characterized as motor oil. CVOCs were not detected in the product sample collected from well SW-7 (Table 2-5). The absence of CVOCs in the product sample was confirmed in a split-sample collected by EPA.

A transient occurrence of floating product was detected in monitoring wells MW-9 and MW-9S, located approximately 60 feet south of the north oil/water separator, between September and November 1992. Specifically, floating product ranging in thickness from a sheen to 0.11 feet was observed in MW-9S, and a product sheen was detected on one occasion in well MW-9. Subsequent measurements during 1994 and 1996 in these two wells demonstrated the absence of a free-floating product layer. Phase-separated hydrocarbons have not been detected in any other wells at or proximal to the Esso Tutu Service Station.

SECTION 3.0

SOURCE CONTROL PROGRAM OBJECTIVES AND DESIGN CRITERIA

The Source Control Program for the Esso Tutu Service Station is designed to remediate petroleum hydrocarbons and chlorinated volatile organic compounds present in site soils (Remedial Work Element I), and dissolved and phase-separated petroleum hydrocarbons present in ground water emanating from the Esso Tutu Service Station (Remedial Work Element II). Per the Tutu Wellfield ROD, Remedial Work Element I will incorporate soil vapor extraction (SVE) and bioventing systems with treatment via catalytic oxidizer to remediate contaminated soils. Remedial Work Element II will incorporate manual bailing of free-phase product and a total fluids extraction system with treatment via air stripper and granular activated carbon to remediate contaminated ground water. This section provides a detailed description of the objectives and design criteria for the Esso Tutu Service Station Source Control Program.

3.1 Target Cleanup Goals of the Source Control Program

The goal of Remedial Work Element I (soil remediation program) will be to reduce to the extent practical the concentration of petroleum hydrocarbons and chlorinated volatile organic compounds (CVOCs) in soil to the site-specific Soil Screening Levels (SSLs) established by the Tutu Wellfield ROD. The following SSLs for individual contaminants were established in the Tutu Wellfield ROD (Table 12) for the Esso Tutu Service Station:

Compound	Depth (feet below surface)	Site-Specific Soil Screening Level
BTEX Compounds	0.0 - 8.7	74 µg/L
CVOCs	0.0 - 8.7	320 µg/L
BTEX Compounds	8.7 - 15.0	15 µg/L
CVOCs	8.7 - 15.0	32 µg/L

The above concentrations will be used as target cleanup goals for soil remedial activities included as part of the Esso Source Control Program.

The goal of Remedial Work Element II (ground-water remediation program) will be to reduce the concentration of contaminants of concern emanating from the Esso Tutu Service Station to Federal MCLs to the extent practical in the localized/shallow portion of the Tutu aquifer beneath, and immediately downgradient of the subject station. For the purposes of the Esso Source Control Program, the shallow portion of the Tutu aquifer is defined as being present within approximately 40 feet of ground surface.

As specified in the Tutu Wellfield ROD, the regional aquifer is classified as a potable drinking water supply. As such, ground-water remediation standards are dictated by Federal Maximum Contaminant Levels (MCLs) and drinking water standards established by the Federal EPA. Contaminants of concern in ground water attributable to operations at the Esso Tutu Service Station (as identified in the ROD), are limited to volatile aromatic hydrocarbons (benzene, toluene, ethylbenzene, and xylenes). The spatial distribution of these compounds in the shallow aquifer was discussed in Section 2.4. Associated MCLs for these compounds (Table 12 of the ROD) are as follows:

Compound	Federal MCL
Benzene	5 µg/L
Toluene	1,000 µg/L
Ethylbenzene	700 µg/L
Xylenes	10,000 µg/L

The above concentrations will be used as target cleanup goals for ground-water remedial activities included as part of the Esso Source Control Program.

3.2 Objectives of the Source Control Program

Objectives of Remedial Work Element I (Soil Remediation) of the Esso Source Control Program to reach the target cleanup goals include:

1. Reduction of residual contaminant mass in vadose zone soils via SVE and bioventing. Although vadose zone modeling of existing soil quality data indicates that residual contaminant mass will not leach to the Tutu Aquifer at concentrations that would result in exceedance of Federal MCLs, unsaturated zone remediation will be performed because access limitations proximal to the gasoline dispenser island did not allow for the collection of potentially "worst case" BTEX impacted soils directly beneath the dispensers. Therefore, soils with BTEX concentrations which could adversely impact ground-water quality potentially exist in this area but have not been sampled.

2. Removal of mobile-phase product and dehydration of the perched zone through manual bailing and total fluids extraction.

Removal of petroleum hydrocarbons in a state of residual saturation from the perched ground-water system will require the implementation of soil bioventing. Although phase-separated hydrocarbons (PSH) in this area exhibit a limited quantity of BTEX compounds and no CVOCs, removal of PSH is required by the EPA.

Objectives of Remedial Work Element II (Ground-Water Remediation) of the Esso Source Control Program to reach the target cleanup goals include:

1. Removal of PSH present in on-site and off-site monitoring wells through: 1) manual bailing; 2) total fluids pumping; and 3) deep SVE in the PSH smear zone. PSH has been observed intermittently at three well locations: SW-3 and CHT-3 (gasoline), and SW-7 (motor oil).

2. The establishment of localized hydraulic control of the Tutu aquifer beneath and downgradient of the Esso Tutu Service Station to prevent BTEX plume expansion.

3. Remediation of dissolved aromatic compounds via total fluids extraction in the shallow portion of the Tutu aquifer beneath and downgradient of the Esso Tutu Service Station. Remediation efforts are designed, to the extent possible, to reduce concentrations of aromatic constituents to levels consistent with Federal Drinking Water Criteria.

Specific design criteria for each remedial objective are presented below. The basis of design for each remedial work element is discussed in Section 4.0 and system components and capacities which will achieve the design criteria are described in Section 5.0.

3.3 System Design & Design Criteria - Remedial Work Element I (Soil Remediation)

This section includes: 1) specific site conditions and technical considerations which must be addressed in the system design, and 2) general system design criteria necessary to achieve the Source Control Program's Target Cleanup Goals and Objectives of Remedial Work Element I.

Remedial activities in the vadose zone soils will consist of soil vapor extraction (SVE) and bioventing. SVE will be performed concurrently with dewatering of the perched water-bearing zone and PSH removal to more effectively achieve contaminant mass removal. Bioventing remedial activities will be performed subsequent to dewatering of the perched water zone. Remedial activities in the saturated zone soils will consist of ground-water recovery (and associated dewatering) and treatment, as well as PSH removal (see Section 3.4)

3.3.1 Vadose Zone Soils

For the purposes of this report, the vadose zone is defined as those areas which are unsaturated, or which will become unsaturated as a result of ground-water and PSH extraction. The term "soil impact" identifies soils which contain contaminants of concern above EPA's SSLs, as presented in the ROD. Two general areas of vadose zone soil impact exist at the Esso Tutu Service Station. These areas of soil impact, and a listing of contaminants detected above their respective SSLs, are as follows:

North Oil/Water Separator		
Benzene	Toluene	
Ethylbenzene	Xylene	
1,1-Dichloroethane	1,2-Dichloroethene	
Tetrachloroethene	Trichloroethene	1,1,1-Trichloroethane

Dispenser Island/Product Delivery Lines	
Benzene	Toluene
Ethylbenzene	Xylene

As noted above, the north oil/water separator and the dispenser island/product delivery line area are characterized by the presence of aromatic constituents. Vadose zone soils proximal to the north oil/water separator also exhibit the presence of several CVOCs above SSLs.

3.3.1.1 North Oil/Water Separator

Vadose zone remedial activities proximal to the north oil/water separator will involve SVE and bioventing to remove residual contaminant mass sorbed onto the soil matrix. Initiation of vadose zone remediation will occur contemporaneous with dewatering of the perched ground-water zone and the removal of PSH, as discussed in Section 3.4. SVE will be utilized to remove volatile organic compounds (e.g., BTEX, PCE, TCE, and DCE) detected in soil samples immediately west of the north oil/water separator. Bioventing, which will be implemented subsequent to SVE operations, will be employed to remediate non-volatile constituents and petroleum hydrocarbons in residual saturation. The configuration of the SVE and bioventing systems is presented in Figure 3-1. SVE in this area will be performed at wells installed to a depth of approximately 15 feet, with 10 feet of screen placed in the 5 to 15-foot interval. The 3 to 12-foot interval represents the zone of highest volatile organic concentrations in this area, and is the area targeted for remediation.

3.3.1.2 Dispenser Island (and UST area)

SVE will be performed proximal to the dispenser island, distribution piping, and USTs to remediate soils impacted by releases of gasoline (Figure 3-1). As stated previously, soils directly beneath the dispenser island have not been extensively sampled, however, based upon ground-water quality data and field observations during the installation of dispenser containment pans in 1995, soils impacted with gasoline product were present directly beneath the dispensers and the distribution piping. In addition, well gauging efforts have indicated the presence of PSH at well SW-3, located approximately 7 feet south of the dispenser island.

Deep SVE wells associated with the SVE dispenser island network (V-4), as well as the UST area (V-5), will each be utilized to remove residual phase-separated hydrocarbons (PSH) from the bedrock aquifer as the water table is lowered during ground-water remediation efforts (Section 3.4). Operation of SVE in the interval of 15 feet to 30 feet below grade at each point will remove residual mass smeared on fractured bedrock as the water table, and thus free product, is lowered due to fluid extraction activities (depth to ground water under static conditions is 17 to 20 feet below grade).

3.3.2 Design Criteria

Site data indicate that the spatial distribution of volatile organic compounds is limited, and that three shallow SVE wells, two deep SVE wells, and five bioventing extraction wells should encompass the area of concern. In Figure 3-2, the average vapor capture zone of 30 feet observed during the 1996 pilot testing program has been superimposed on known extent of soil impact above applicable SSLs to illustrate the calculated/expected zone of SVE/biovent capture. The capture zones will be established at an applied vacuum remediation system vacuum of 20 inches of water column (wc) and a flow rate of 15 to 20 cubic feet per minute (cfm) for each extraction well and 3 to 5 cfm for each bioventing extraction well.

At present, based on pilot test data and experience with similar systems, it is anticipated that the SVE system will operate for approximately 24 to 36 months. The transition from SVE to bioventing will be determined based upon field monitoring and/or laboratory analysis of vapor concentrations during system operation, as discussed in the O&M Manual.

The basis of design for Remedial Work Element I is discussed in Section 4.1, and system components and capacities are described in Section 5.1.

3.4 System Design & Design Criteria - Remedial Work Element II (Ground Water)

This section includes: 1) specific site conditions and technical considerations which must be addressed in the system design; and 2) general system design criteria necessary to achieve the Source Control Program's Target Cleanup Goals and Objectives of Remedial Work Element II.

The ground-water remedial program has been designed to achieve two principal objectives: 1) reduction of aromatic hydrocarbon mass in the defined BTEX plume; and 2) establish localized hydraulic control to prevent BTEX plume expansion.

Ground-water remedial activities will consist of ground-water recovery and treatment, and PSH recovery. These activities will be implemented in both the perched water-bearing zone and the shallow portion of the Tutu aquifer underlying the Esso Tutu Service Station.

3.4.1 Perched Water Zone

As discussed in Section 2.1, a localized perched ground-water zone is present in the southwestern portion of the station property, proximal to the north oil/water separator (Figure 2-1). Depth to water in the perched zone is approximately 9 feet to 10 feet below grade and water elevations in the perched zone have historically been consistently 8 feet to 10 feet higher than water levels in the shallow portion of the Tutu aquifer.

3.4.1.1 Dissolved VOCs/Dewatering Activities

The objective of the extraction process in the perched water-bearing zone will be to dewater this unit so that SVE and bioventing operations will be able to more effectively remove contaminant mass. As such, the four shallow extraction wells (Figure 3-1) will function as well points, serving to draw down the level of water throughout the entire perched zone. The four extraction wells proximal to the north oil/water separator were each installed to a depth of 15 feet below grade. The remedial system will process and effectively treat any dissolved volatile organic compounds (VOCs) recovered during dewatering activities.

In conjunction with dewatering activities in the area proximal to the north oil/water separator, the source of the water to this unit will be identified and mitigated to the extent possible. Based upon field observation recorded in 1993 and 1996, there does not appear to be any horizontal flow of water onto the Esso Tutu Service Station that is contributing water to the perched zone. At present, it is believed that the source of water in the perched zone is related to the cistern located beneath the station building, or infiltration of storm water through cracks/voids in the pavement. Identification of the actual source of water will be performed through an evaluation of cistern integrity.

3.4.1.2 Phase-Separated Hydrocarbons (PSH)

The spatial extent of PSH at SW-7 is limited by the size of the perched water zone, which is estimated to be less than 4,250 square feet. Recovery of PSH will initially be implemented through periodic manual bailing of product from product-bearing wells. Termination of the manual bailing program will occur when free product is no longer detected at significant thicknesses (i.e., greater than 0.05 feet) in area wells.

PSH removal will also be accomplished via total fluids extraction from the perched water-bearing zone proximal to the north oil/water separator by the four shallow recovery wells (Figure 4-1). Subsequent to completion of the PSH recovery phase, pumping activities will continue to recover contaminated ground water. Concurrent with free product bailing and the ground-water extraction program, the SVE system will be activated to remove residual petroleum mass sorbed to dewatered soils/consolidated rock.

3.4.2 Localized/Shallow Portion of the Tutu Aquifer

Ground water associated with the water table aquifer is present at depths of 17 to 20 feet beneath the site. For the purposes of the Esso Source Control Program, the shallow portion of the Tutu aquifer is defined as being present within approximately 40 feet of ground surface. Although chemical properties of the water table aquifer vary with depth, shallow and deep portions of the aquifer are believed to comprise a single hydrogeologic unit.

3.4.2.1 Dissolved VOCs

The ground-water remedial program in the localized/shallow portion of the Tutu Aquifer has been designed to achieve two principal objectives: 1) reduction of aromatic hydrocarbon mass in the defined BTEX plume; and 2) establish localized hydraulic control to prevent BTEX plume expansion. The ground-water remedial system associated with the localized/shallow portion of the Tutu aquifer is expected to operate until dissolved VOC concentrations are reduced to MCLs, or until concentrations demonstrate an asymptotic relationship with respect to time. The Source Control Program has not been designed to address CVOCs associated with the "Northern CVOC Plume", which emanates from the Curriculum Center, or the "deep" BTEX plume which emanates from the Texaco Service Station.

Ground-water extraction activities will be employed to address dissolved VOC contamination. The downgradient extent of the dissolved BTEX plume is defined by wells MW-9, MW-10, MW-10D, and CHT-7D. Although MW-10D and CHT-7D are deep wells, they provide information regarding the vertical limits of BTEX contamination.

Four deep extraction wells have been installed to facilitate requisite pumping rates and achieve the stated goal of arresting plume expansion and reducing contaminant mass. Three of the four extraction wells (G6, G7, and G8 - approximately 80 feet south of the property line) will be installed near the downgradient border of the Esso Tutu Service Station, while the fourth well (G5) will be placed proximal to the dispenser island (see Figure 4-1).

3.4.2.2 Phase-Separated Hydrocarbons (PSH)

The remedial program for the Esso Tutu Service Station will incorporate the removal of phase-separated hydrocarbons (PSH) from both on-site and off-site locations. As previously discussed, PSH has been observed on an intermittent basis at wells CHT-3 and SW-3, which are screened in the shallow portion of the regional aquifer. CHT-3 is located on the adjacent Splash-n-Dash property, just south of the existing Esso UST field; SW-3 is located proximal to the Esso dispenser island. PSH recovery from the shallow Tutu aquifer will be performed at deep extraction well locations proximal to CHT-3 and SW-3 (Figure 3-1). PSH recovery will be accomplished through total fluids extraction and/or periodic manual bailing. Concurrent operation of the deep SVE system in these areas will also enhance PSH removal.

3.4.3 Design Criteria

Site data indicate that four shallow extraction wells should be sufficient to dewater the perched water zone and four deep extraction wells will establish hydraulic control across the area of concern. Data from pumping tests conducted as part of the Remedial Action Work Plan demonstrated that the perched water-bearing unit can sustain pumping rates of approximately 0.5 gallons per minute (gpm). Based on pilot testing, sample purging and recovery data, and slug test results, the anticipated recovery rate from the four deep ground-water extraction wells will be from 0.5 to 1.0 gpm. The total pumping rate from the eight extraction wells is estimated at 3 to 6 gpm, although the recovery rate may be slightly higher during initial system operation.

Figure 3-3 depicts the calculated/expected hydraulic capture zones that will be generated as a result of operation of the SCP, superimposed on the area where benzene exceeded the Federal MCL. Figure 3-3 illustrates that a pumping rate of 0.50 gpm from each of the four deep extraction wells will provide complete hydraulic control and maximum reduction of contaminant mass. Field monitoring will be conducted subsequent to system start-up to confirm that sufficient capture has been generated (see Section 6.0).

At present, based on pilot test data and experience with similar systems, it is anticipated that the ground-water remediation program will likely operate for a period of 5 years to 10 years. The compound controlling the anticipated duration is benzene, and its associated drinking water standard of 5 µg/L. Actual termination of the regional aquifer ground-water remedial program will be based upon adherence to Federal MCLs, or achievement of asymptotic concentrations. Data utilized to assess termination of the remedial system, as well as system effectiveness, will be collected through institution of a site compliance monitoring program (see Section 6.0).

The basis of design for Remedial Work Element II is discussed in Section 4.2, and system components and capacities are described in Section 5.2.

SECTION 4.0

BASIS OF DESIGN

This section outlines the assumptions, data analyses, and calculations that were used to develop the design criteria presented in Section 3.0. Each item also includes a discussion of the contingencies that will be employed in the event that the design criteria are not achieved. Selection of specific remedial system equipment components, system operational capacities, and associated contingencies are discussed in Section 5.0.

4.1 Remedial Work Element I - Basis of Design

Design criteria for Remedial Work Element I (Soil Remediation) include: 1) five SVE wells with a flow rate of approximately 15-20 cfm per well and an effective radius of influence of approximately 30 feet (Figure 3-2); 2) five bioventing extraction wells with a flow rate of approximately 3-5 cfm per well; 3) five bioventing injection wells with a flow rate of approximately 3-5 cfm per well; 4) a contaminant mass removal rate of 0.05 to 0.61 pounds per hour; and 5) effective treatment of recovered vapors via catalytic oxidation.

4.1.1 Radius of Influence

The design criteria used an effective radius of influence of 30 feet for each SVE/BE well. Results from the two pilot tests suggest that this is a conservative estimate. During the pilot test which utilized SW-3 (proximal to the dispenser island) as the extraction well, a vacuum of 20 inches of water column (wc) at the wellhead resulted in an induced vacuum of 0.06" wc at a monitoring well (SW-1) located over 40 feet from SW-3. At a wellhead vacuum of 58" wc, an induced vacuum of 0.15" wc was recorded in a monitoring well (VW-4) located more than 60 feet from the extraction well. Pilot test results are summarized in Table 4-1 and additional supporting information is provided in Appendix A.

There appear to be some preferred air flow pathway directions at lower vacuum levels; however, at maximum vacuum (58" wc), induced vacuum is closely correlated with distance except for VW-6 (Figure 4-1). The lower than expected value at VW-6 may be a result of subsurface heterogeneities or possible short-circuiting in the vicinity of VW-6.

During the pilot test which utilized VW-3 (south of the station building) as the extraction well, a vacuum of 20" wc at the wellhead resulted in induced vacuums of 0.28" wc at SW-7 (5 feet from VW-3), and 0.04" wc in three monitoring wells located more than 15 feet from the extraction well (Table 4-1). Increased vacuum at VW-3 resulted in correspondingly higher induced vacuums at the monitoring wells. Vacuum influence (greater than 0.01" wc) was not recorded in VW-3, located 45 feet from VW-3.

During the same pilot test, an induced vacuum of 0.05 was initially recorded in SW-8, located approximately 37 feet from VW-3; however, influence was not recorded at higher wellhead extraction vacuums. These results, which suggest that short-circuiting developed near SW-8 during testing, are corroborated by a third pilot test which attempted to utilize SW-8 as the extraction well. Vacuum influence could not be induced in any monitoring points again implying that short-circuiting was occurring in the vicinity of SW-8. Although induced vacuum was not maintained, the initial response recorded at SW-8 indicates that the area of influence extended approximately 40 feet during the VW-3 pilot test.

The design criteria incorporates a radius of influence (30 feet) that is conservatively less than the recorded pilot test values (40 feet, and greater than 60 feet). The large areal extent of influence observed during pilot testing is not surprising given that the entire surface of the site is paved with impervious asphalt or concrete. Unless short-circuiting occurs, vapor capture zones will essentially extend to the boundaries of the site.

Bioventing extraction will be performed at lower flow rates than SVE activities. The resulting difference in radius of influence could not be quantified from the available pilot test data; however, due to the paved surface it is expected that the radius of influence will be similar to that predicted for SVE, but that overall mass removal will be lower during bioventing activities. If necessary, higher flow rates can be generated from the bioventing extraction wells.

During system operation, if vapor monitoring points (VMPs) indicate that the actual area of influence is less than the design basis value, the radius of influence can be increased by: 1) utilizing existing bioventing extraction wells as additional extraction points during SVE activities; 2) installing additional SVE wells; 3) temporarily opening/closing valving at individual extraction wells as needed to increase air flow in areas showing less vacuum response; and 4) installing 1.5-inch diameter PVC wells via hand auger through the paved surface to a depth of approximately three feet. These "dry wells", which could also serve as supplemental VMPs, would be vented to the atmosphere and serve as "passive" air injection wells. Passive air injection wells would create preferred pathways that will extend the area of vapor capture and counteract any directional capture effects caused by heterogeneities in the fill and native soils, and subsurface utility lines.

4.1.2 Ability to Monitor Capture Zones

Numerous VMPs are located near each extraction well for the determination of vapor capture zones during actual system operation (Table 4-2). VMP locations were selected to optimize monitoring capabilities. Each VMP can be used to monitor more than one extraction well by temporarily opening or closing valving at individual extraction wells as needed. The existing VMP array should be sufficient for all monitoring purposes. If necessary, additional VMPs can be installed via hand auger as described in Section 4.1.1.

4.1.3 Air Flow

The predicted air flow from each of the five SVE wells was estimated at 15 to 20 cfm at 20" wc for the design basis. This estimate is based on the results of two SVE pilot tests performed at the site. Reliable air flow readings were obtained during conditions of maximum vacuum (low flow). Air flow was approximately 15-18 standard cubic feet per minute (scfm) at an applied vacuum of 58" wc on SW-3 and 18-20 scfm at an applied vacuum of 53" wc on VW-3 (Table 4-1). Air flow readings were not obtained at lower vacuum conditions due to interference caused by the air dilution mechanism. Based on the performance curve (Appendix A) for the vapor extraction system blower (see Section 5.1.3), a total design flow of approximately 100 cfm (15-20 cfm from each of the five extraction wells) at a wellhead vacuum of 20" wc was incorporated into the system design.

If actual flow rates during system operation are significantly lower than predicted, flow can be increased by: 1) utilizing existing bioventing extraction wells as additional extraction points during SVE activities; 2) installing additional SVE wells; and 3) installing additional VMPs (Section 4.1.1) which would be vented to the atmosphere and serve as passive air injection wells.

The system design calls for an extraction air flow rate during bioventing activities (3-5 cfm from each well, total flow 15-25 cfm) that is significantly lower than SVE air flow rates (total flow 80-100 cfm). Based on the aforementioned pilot test data, the bioventing extraction flow rates are attainable and further analysis was not performed.

The bioventing system design also includes a compressor that will deliver air to five bioventing injection wells. Although the proposed air injection rate (3-5 cfm for each well) has not been confirmed via pilot testing, the compressor has adequate capacity to allow the injection flow rate to be field-adjusted as necessary. Equipment details are provided in the Project Manual/Technical Specifications. Additional ambient air can be provided to the subsurface during bioventing activities through the use of passive injection wells described above.

4.1.4 Vapor Contaminant Mass Removal and Treatment

The estimated rate of VOC mass removal during the initial operation of the SVE system is approximately 1.2 to 15 pounds per day. This estimate is based on the results of the vapor samples collected during the two SVE pilot tests performed at the site (analytical results are included in Appendix A). Table 4-3 summarizes relevant conversions and mass removal at total SVE/bioventing air flow rates of 125 cfm (average system air flow) and 175 cfm (maximum system air flow) based on average vapor sample concentrations (Table 4-3a) and maximum vapor sample concentrations (Table 4-3b). Mass removal based on maximum vapor concentrations was used for system treatment and design purposes.

Initially, vapor concentrations recovered by SVE wells may exceed the concentrations detected during pilot testing, but a "richer" extracted vapor stream will actually result in lower supplemental propane consumption by the catalytic oxidizer treatment unit without any loss of treatment removal efficiency. The catalytic oxidizer, which uses supplemental propane to maintain an optimal thermal destruction temperature, has a minimum treatment efficiency of at least 95%. The 95% treatment efficiency was used to calculate effluent discharge quantities for air pollution control permitting (see Section 8.0). Catalytic oxidizer equipment details are provided in the Project Manual/Technical Specifications. If increased vapor concentrations cause an increase in effluent air emissions, the influent air stream can be temporarily diluted to maintain effluent concentrations within the discharge limits specified by the permit.

During the course of SVE activities, vapor concentrations recovered by SVE wells will decrease until they are significantly lower than the concentrations detected during pilot testing and begin to approach an asymptotic limit. The asymptotic limit will be used to determine when SVE activities will be terminated and vapor remediation will be restricted to bioventing (which will also reach a secondary asymptote). The asymptotic limits and the rate of vapor concentration decrease cannot be accurately predicted until extended field operation of the system. If the general performance of Remedial Work Element I during actual operation is not consistent with the design criteria, general performance contingencies discussed in Section 6.2 will be invoked.

At present, based on pilot test data and experience with similar systems, it is anticipated that the SVE system will operate for a period of 24 to 36 months. This time estimate is based on and contingent upon a number of assumptions because influent contaminant concentrations, flow rates, and other system performance factors cannot be determined with certainty until actual field operation of the SVE system. Field data, assumptions, and calculations used to estimate the duration of SVE activities are included in Appendix A.

4.2 Remedial Work Element II - Basis of Design

Ground-water remedial activities will consist of PSH recovery and ground-water recovery and treatment. These activities will be implemented in both the perched water-bearing zone and the shallow portion of the Tutu aquifer underlying the Esso Tutu Service Station.

Design criteria for Remedial Work Element II (Ground-Water Remediation) include: 1) four shallow total fluids extraction wells with expected flow rates ranging from approximately

0.25 to 0.50 gpm per well; 2) four deep ground-water total fluids extraction wells with expected flow rates ranging from approximately 0.50 to 1.0 gpm per well and an effective hydraulic capture zone similar to that illustrated in Figure 3-3; 3) an anticipated contaminant mass removal rate of 0.08 pounds per hour; and 4) effective primary treatment provided by an air stripper with secondary treatment via granular activated carbon (GAC).

4.2.1 Ground-Water Extraction Rates

The anticipated ground-water extraction rate is 0.5 to 1.0 gpm for the four deep recovery wells, and 0.25 to 0.50 gpm for the four shallow (perched water zone) recovery wells. These extraction rates are based on pilot test results, sample purging flow rates and recharge rates, and slug tests performed at the site.

Pumping tests were performed utilizing SW-1, SW-3, SW-7, and CHT-2 as extraction wells. Construction details for all remedial system and monitoring wells are provided in Table 3-1. SW-1 (located proximal to the UST field) and SW-3 (located proximal to the dispenser island) are screened from 5 feet below surface grade (bsg) to the bottom of the well (34 and 39 feet bsg, respectively). SW-7 (perched zone proximal to the station) is a 4-inch diameter well screened from 7 to 22 feet bsg, and CHT-2 (immediately west of the property line) is a 2-inch diameter well screened from 31 to 36 feet bsg.

Pumping test and sample purging results were similar for SW-1 and SW-3. Neither well could sustain a pumping rate of 0.5 gpm for more than 45 minutes and ground-water recharge to both wells was slow. Drawdown was not observed in monitoring wells during either test because the pumping duration was too short and the nearest monitoring points were more than 30 feet from the extraction wells.

In contrast, SW-7 sustained a pumping rate of 0.5 gpm for over three hours (however, the well was quickly dewatered when the pumping rate was increased to 0.75 gpm), and 99% ground-water recovery occurred within 15 minutes of the cessation of pumping. Drawdown was not observed in monitoring wells MW-9, MW-9S, or SW-8 which are all located more than 35 feet from SW-7. The higher yield during the SW-7 pumping test is evidence for the presence of the perched water zone, and this pumping rate was used as a general recovery rate for the four shallow extraction wells which are also screened across the perched water zone.

CHT-2 sustained a pumping rate of 0.5 gpm for over two hours and 58% ground-water recovery occurred within 76 minutes of the cessation of pumping. Drawdown was observed in the following monitoring wells: MW-9S (0.43 feet; less than 10 feet from CHT-2), MW-9 (0.10 feet, approximately 20 feet from CHT-2) and SW-8 (0.05 feet, approximately 50 feet from CHT-2). Drawdown was not detected in SW-7 which is located approximately 40 feet from CHT-2. A distance-drawdown plot for the CHT-2 pumping test is included in Appendix A. These results suggest that: 1) the perched water zone was not influenced by pumping from the deeper interval (no response in SW-7), and 2) although the sustainable pumping rate from this 2-inch diameter well was less than 0.50 gpm, pumping from this interval can generate an extensive hydraulic capture zone (see Section 4.1.2).

Sample purging data from MW-8, MW-9S, MW-9, and MW-10, indicated that at least three well volumes could be purged from these wells at a rate of 0.5 gpm. Sustainable pumping rates are probably similar to CHT-2. In contrast, MW-10D, a six-inch diameter deep well (total depth 75 feet), sustained a purge rate of approximately 2.0 gpm for 40 minutes, and CHT-7D, a six-inch diameter deep well (total depth 124 feet), sustained a purge rate of more than 3.0 gpm for over two hours. Pumping tests were not performed at these wells, but the purging results suggest that wells which intercept the shallow portion of the Tutu aquifer (minimum depth 40 feet) are capable of sustaining significantly higher pumping rates. The deep wells installed as part of the remedial system are of similar construction: 6-inch diameter and total depths of 60 feet and can be expected to sustain similarly higher pumping rates. In addition, the system's deep extraction wells have a screened interval of 45 feet (vs. five feet for CHT-2 and 20 feet for MW-10D) which should enhance ground-water recovery efforts.

Hydraulic conductivities were calculated by entering pumping test data and slug test data into the AQTESOLVE modeling program (Geraghty & Miller), and analyzing using the Theis, Cooper-Jabob, and Moench methods. Input parameters are summarized in Table 4-4; pumping curves from pilot testing are included in Appendix A. Hydraulic conductivities which were based on both pumping and monitoring well data, and pumping and rebound/recovery data where available, were relatively consistent within each hydraulic zone/well type:

Hydraulic Zone	Average Permeability
Perched Water Zone - Pumping Well	4.3 EE-4 ft/min
Shallow Bedrock (<40 feet)	4.2 EE-4 ft/min
Pumping Wells	3.9 EE-5 ft/min
Monitoring Wells	1.0 EE-3 ft/min
Deeper Bedrock (>40 feet) - Slug Test	1.0 EE-5 ft/min
Site Average	1.0 EE-4 ft/min

If actual flow rates during system operation are significantly lower than predicted and the performance of Remedial Work Element II is not consistent with the design criteria, general performance contingencies discussed in Section 6.4 will be invoked. The contingencies could include the installation of supplemental ground-water recovery wells or the incorporation of additional technologies such as dual-phase vacuum extraction or hydro-fracturing to increase recovery well yields.

If well yields and flow rates during system operation are higher than predicted, the system components have the additional capacity to allow extraction flow rates to increase to a maximum operational system flow of 12 gpm (up to 1.0 gpm from individual shallow wells and up to 3.5 gpm from individual deep wells. Equipment capacity is discussed in Section 5.2.4 and equipment details are provided in the Project Manual/Technical Specifications. If well yields prevent the dewatering of the perched water zone, general performance contingencies discussed in Section 6.4 will be considered. During the interim period, continued removal of perched water with concurrent recharge via the station cistern and/or roof drains will "flush" residual contaminants from the perched water zone to the shallow recovery wells.

4.2.2 Hydraulic Capture Zones

Analysis of pilot test data indicate that the four deep extraction wells (G5, G6, G7, G8) will achieve the stated goal of arresting plume expansion and reducing contaminant mass. An analytical hydraulic model (Quick Flow, Geraghty & Miller) combined the following site-specific input parameters:

Hydraulic Conductivity	0.144 ft/day
Aquifer Thickness	80 feet
Hydraulic Gradient	0.04
Storativity	0.00001
Porosity	0.10
Pumping Rate	0.25 gpm (Figure 4-2)
	0.50 gpm (Figure 4-3)

with an idealized hydraulic gradient map for the site (Figure 4-1) to generate the hydraulic capture zones depicted on Figure 4-2 (flow rate of 0.25 gpm) and Figure 4-3 (flow rate of 0.50 gpm). The two figures indicate that the four deep recovery wells should achieve complete hydraulic control across the site at pumping rates of 0.25 gpm and 0.50 gpm, and prevent plume expansion.

Hand calculations were performed to confirm the hydraulic capture zones generated by the model (for a summary of hand calculations, see Appendix A). The calculations provide verification of model results and generate downgradient capture zones (i.e., distance from well to capture zone toe) of 17 feet, 33 feet, and 66 feet at pumping rates of 0.25 gpm, 0.50 gpm, and 1.0 gpm, respectively. Figure 3-3 depicts the calculated/expected hydraulic capture zones that will be generated as a result of operation of the SCP, superimposed on the area where benzene exceeded the Federal MCL, illustrating that the four deep extraction wells will provide maximum reduction of contaminant mass. Field monitoring will be conducted subsequent to system start-up to confirm that sufficient capture has been generated.

The design criteria incorporates an area of hydraulic control that is larger than the area of influence observed during pilot testing; however, an area of influence which extended over 50 feet was observed during the CHT-2 pumping test. Other pilot tests were performed using shallower and smaller diameter recovery wells (see Section 4.2.1), and pilot tests were concluded upon initial dewatering of the extraction wells. The use of water level controlled pneumatic pumps will allow recharge to the recovery well after each cycle of extraction and result in the dewatering of a progressively larger area along the steepened hydraulic gradient generated by extraction at the well.

Existing monitoring wells located in the vicinity of each deep ground-water extraction well will be utilized for the determination of hydraulic capture zones during system operation (Table 4-5). The effectiveness of the shallow ground-water wells will be indicated by dewatering of the perched water zone.

During system operation, if the general performance of Remedial Work Element II is not consistent with the design criteria due to a reduced area of hydraulic capture or inability to dewater the perched water zone, general performance contingencies discussed in Section 6.4 will be invoked.

4.2.3 PSH Volume and Recoverability

The maximum "apparent" thickness of PSH ever detected in any well at, or proximal to, the Esso Tutu Service Station is 0.34 feet (SW-7, September 19, 1996). Liquid-level data are summarized in Table 2-4. Although product baildown tests have not been performed at the Site, field observations suggest that the "true" product thickness is most likely in the range of 0.01 feet to 0.10 feet. This range is supported by well gauging data collected during and subsequent to pilot pumping test activities which indicated that free product accumulation in site wells did not exceed an apparent thickness of 0.07 feet in SW-3, and 0.05 feet in SW-7 and CHT-3.

The extent and distribution of PSH is limited both horizontally and vertically. The spatial extent of PSH at SW-7 is limited by the size of the perched water zone, which is estimated to be less than 4,250 square feet. The absence of PSH in monitoring well SW-1 serves to separate the two free product areas observed at CHT-3 and SW-3, which are isolated from one another by approximately 35 feet.

Using "true" PSH thicknesses of 0.05 feet for SW-7 and CHT-3, and 0.07 feet for SW-3, assumed porosities of 0.25 for unconsolidated soils proximal to SW-7 and 0.15 for bedrock in the vicinity of SW-3 and CHT-3, the estimated volume at each of the three areas with previously detected product is:

Monitoring Location	Approximate Areal Extent	Estimated PSH Volume	System Recovery Wells
SW-7	4250 sq. ft.	400 gallons	G2, G3, G4
SW-3	500 sq. ft.	40 gallons	G5
CHT-3	250 sq. ft.	15 gallons	G8

Top-loading, total fluids pumps will initially be positioned in the extraction wells for optimal recovery of PSH. Subsequent ground-water drawdown will form a cone of depression that will direct product flow to the extraction wells listed in the above table. Product recoverability pilot tests have not been performed and PSH recovery rates cannot be determined until actual system operation. After the perched water bearing zone is dewatered in the vicinity of SW-3, residual PSH in vadose soils will be removed via SVE and bioventing activities. Deep SVE wells will be used to remove residual PSH from bedrock in the vicinity of SW-3 (V4) and CHT-2 (V5). Additional general performance contingencies for PSH recovery are described in Section 6.4.

4.2.4 Ground-Water Contaminant Mass Removal and Treatment

The estimated rate of VOC mass removal during the initial operation of the ground-water extraction system is approximately 2 pounds per day at a total system extraction rate of 6 gpm (0.5 from each shallow well and 1.0 gpm from each deep well). Laboratory analytical results from ground-water samples collected during the RD pilot testing program (September/October 1996) were used to derive mass-loading calculations. Representative well(s) in the vicinity of each ground-water recovery well were used to predict contaminant concentrations during system operation. Sampling data from SW-7 were used to characterize the four shallow extraction wells, and sampling data from one to four monitoring wells were used to characterize expected contaminant concentrations from each of the four deep recovery wells (Table 4-6). Ground-water analytical data is summarized in Table 2-3. The flow contribution from each well was also weighted (deep wells contributing twice the flow of shallow wells) before calculating total flow concentrations and design concentrations (Table 4-6). Maximum expected flow rates were used in the calculations to ensure adequate treatment capacity. Table 4-7 summarizes the laboratory results, relevant conversions, and mass removal at total ground-water extraction rates of 6 gpm (expected system flow), 10 gpm (maximum operational system flow), and 12 gpm (maximum system design flow).

The air stripper incorporated into Remedial Work Element II was selected such that at a flow rate of 15 gpm and contaminant concentrations outlined in Table 4-7, the air stripper would reduce contaminant concentration to meet the discharge limits stipulated in the site's Territorial Pollution Discharge Elimination System (TPDES) permit (see Section 8.0). Additional information on equipment capacity and contingencies is discussed in Section 5.2.4.

Air stripper treatment efficiency was modeled using ShallowTray's (manufacturer) proprietary software (ShallowTray Modeler v.2.1W) and the design concentrations specified in Table 4-6. A description of the software is included in Appendix A. Technical specifications for the air stripper are available in the Project Manual/Technical Specifications. The specifications require that the final air stripper manufacturer/model meet performance criteria that are equal or better to the model results for ShallowTray Model 2341.

The model output (Appendix A) indicates that predicted benzene treatment efficiencies will be 100% at flow rates between 6 and 12 gpm, and 99.9997% at the maximum instantaneous system flow capacity of 15 gpm. Benzene, toluene, and xylene concentrations will remain below 1 part per billion (ppb) at a flow rates of 15 gpm after treatment via air stripper. Since benzene has the lowest discharge limit (15 ppb), the modeling results demonstrate that the air stripper can provide effective treatment to process water at flow rates above the maximum operational design of 12 gpm. Residence time in the air stripper, and the corresponding treatment efficiency, will be even greater at the lower operational flow rate of 6 to 10 gpm. If higher than expected ground-water concentrations are encountered during initial system operation, the additional treatment capacity will allow the air stripper to effectively treat concentrations spikes at operational flow rates of 6 gpm or less. The use of a holding/equalization tank will mitigate spike contaminant concentrations recovered from individual extraction wells.

Process water will receive final "polish" via two, 55-gallon capacity (200 pounds of carbon) GAC vessels arranged in series. Although the above design calculations indicate that no secondary treatment (GAC) is required, the GAC vessels are incorporated into the treatment system as a precautionary measure.

Mass calculations indicate that total air emissions from the air stripper will be approximately 0.078 pounds per hour. This estimate is derived assuming design volatile organic concentrations, 100% removal efficiency of these constituents during residence time in the air stripper, and an operational flow rate of 6 gpm. Under similar assumptions, total air emissions from the air stripper will be approximately 0.130 pounds per hour at a flow rate of 10 gpm, and 0.156 pounds per hour at a flow rate of 12 gpm. Air stripper emission calculations are summarized in Table 4-7. Based upon these calculations and DPNR permitting (see Section 8.0), vapor-phase treatment of air stripper emissions is not required.

If higher than expected ground-water VOC concentrations result in an increase in effluent air emissions, the Remedial Work Element II treatment system will be configured so that a portion of the air stripper off-gas can be directed to the Remedial Work Element I catalytic oxidizer for treatment. Ground-water recovery rates can also be temporarily reduced to maintain effluent concentrations within the discharge limits specified by the permit. Influent VOC concentrations to the ground-water treatment system will be monitored to determine whether a change in air treatment technology is necessary subsequent to system start-up.

During the course of Remedial Work Element II, VOC concentrations in ground water recovered by system extraction wells will gradually decrease until they are significantly lower than the concentrations detected during prior sampling events and begin to approach an asymptotic limit. The asymptotic limit and the rate of dissolved VOC concentration decrease cannot be accurately predicted until extended field operation of the system. If the general performance of Remedial Work Element II is not consistent with the design criteria due to a lower rate of mass removal, general performance contingencies discussed in Section 6.4 will be invoked.

At present, based on pilot test data and experience with similar systems, it is anticipated that the ground-water remediation program will likely operate for a period of 5 years to 10 years. This time estimate is based on and contingent upon a number of assumptions because influent contaminant concentrations, flow rates, and other system performance factors cannot be determined with certainty until actual field operation of the SVE system. Field data, assumptions, and calculations used to estimate the duration of SVE activities are included in Appendix A.

SECTION 5.0

SYSTEM COMPONENTS, CAPACITIES, AND OPERATIONAL CONTROLS

This section discusses the individual system components which have been incorporated into Remedial Work Element I and II in order to meet the design criteria specified in Section 3.0. General equipment information, including operational design capacities and contingencies such as fault controls, are included where appropriate. More detailed information on system components and overall system operation can be found in the Project Manual/Technical Specifications and the O&M Manual. Manufacturer's cut sheets for system components are also included in the O&M Manual. As required in the technical specifications, any equipment substitutions/changes during construction must result in equal or better system performance.

5.1 Remedial Work Element I (Soil Remediation)

System components for Remedial Work Element I (Soil Remediation) include: 1) five SVE wells (three shallow wells and two deep wells) with a flow rate of approximately 15-20 cfm per well; 2) five bioventing extraction wells and five bioventing injection wells with flow rates of approximately 3-5 cfm per well; 3) a manifolded piping system connecting the wells to the treatment enclosure; 4) system blowers/compressors to extract and inject air; 5) a moisture separator; and 4) treatment of vapors via a catalytic oxidation unit.

5.1.1 Remedial Work Element I - Wells

Three shallow SVE wells, V1 and V2 proximal to the north oil/water separator, and V3 proximal to the dispenser island (Figure 3-1), are installed to a depth of 15 feet below grade. Well construction details include the following (see Table 3-1 and Sheet G-7):

- 2-inch diameter well casing and screen (PVC);

- 10 feet of 0.01 slot well screen, placed at the interval of 5 to 10 feet below grade;
- 5 feet of well riser placed from ground surface to a depth of approximately 5 feet below grade; and,
- completion of a well vault flush with the surrounding grade.

Two deep SVE wells, V4 proximal to the dispenser island and V5 proximal to the UST field (Figure 3-1), have each been installed to a depth of approximately 30 feet below grade. Well construction details include the following (see Table 3-1 and Sheet G-7):

- 2-inch diameter well casing and screen (PVC);
- 15 feet of 0.01 slot well screen, placed at the interval of 15 to 30 feet below grade;
- 15 feet of well riser placed from ground surface to a depth of approximately 15 feet below grade; and,
- completion of a well vault flush with the surrounding grade.

SVE wells will be connected to a single PVC manifold installed in the main remediation piping trench (Figure 3-1). Each SVE well will be equipped at the wellhead with a valve to regulate air flow to allow greater flexibility with respect to altering flow rates in various areas and isolating portions of the remedial system if necessary to meet necessary design criteria. Each SVE well will also be equipped with a sampling port, flowmeter (velocity), and vacuum indicator, so that individual air flows and mass removal rates can be determined for each SVE well. Wellhead connections are shown on Sheet M-2.

The five bioventing extraction wells (BE1 through BE5) and bioventing injection well B1 are installed to a depth of 15 feet below grade. Well construction details include the following (see Table 3-1 and Sheet G-7):

- 2-inch diameter well casing and screen (PVC);
- 10 feet of 0.01 slot well screen, placed at the interval of 10 to 15 feet below grade;

- 5 feet of well riser placed from ground surface to a depth of approximately 5 feet below grade; and,
- completion of a well vault flush with the surrounding grade.

The four shallow ground-water recovery wells (see Section 5.2.1) will be equipped for later use as bioventing injection wells, as such their construction will be 4-inch diameter PVC.

Bioventing extraction and injection wells will be connected to separate PVC manifolds installed in the main remediation piping trench (Figure 3-1). Each bioventing well will be equipped at the wellhead with a valve to regulate air flow to allow greater flexibility with respect to altering flow rates in various areas and isolating portions of the remedial system if necessary to meet necessary design criteria. Each bioventing injection well will be equipped with a flowmeter (velocity) and pressure indicator, so that individual air injection rates can be determined for each well. Each bioventing extraction well will be equipped with a sampling port, flowmeter (velocity), and vacuum indicator, so that individual air flows and mass removal rates can be determined for each well. Wellhead connections are shown on Sheet M-2.

5.1.2 Remedial Work Element I - Piping System

The piping layout associated with remedial Work Element I will consist of three manifolded networks (for detailed piping layout see Sheet M-3):

- North Oil/Water Separator & Dispenser Island/UST - SVE Extraction
- North Oil/Water Separator - Bioventing Extraction
- North Oil/Water Separator - Bioventing Injection

One manifold system will connect all SVE wells. The extraction manifold connecting the three SVE wells located in the UST and dispenser island area will be 3-inch diameter PVC, installed below grade. The extraction manifold will also connect the two SVE wells proximal to the north oil/water separator. The manifold pipe in this area will be expanded to 4-inch diameter PVC. All piping will be installed below grade.

Two manifolds will be associated with the bioventing system, one for the collection of vapors, and the second utilized to facilitate the injection of ambient air. The extraction manifold will connect each of the five biovent points within the alleyway and proximal to the north oil/water separator. Similarly, air injection associated with bioventing activities will be accomplished through five points, all connected to a single manifold leading from the treatment area. All manifold pipe will be 3-inch diameter PVC, installed below grade.

Intermediate, fluid-tight pull stations will house major PVC piping connections and provide a knock-out standpipe for collection of any vapor condensate or entrained ground-water collected during vapor extraction. Detailed engineering design plans for piping and trenching runs are provided on Sheets M-1 and M-3.

5.1.3 Remedial Work Element I - Treatment System Layout and Controls

Soil vapors will be extracted from the five SVE and five bioventing extraction wells using a skid-mounted, Rotron-brand Model EN/CP6, explosion-proof, regenerative blower. Extracted vapors will be pulled through a 30-gallon capacity moisture separator, an in-line filter, and the blower. SVE system flow pathways are summarized on the Process Flow Diagram (Sheet T-2) and flow concentrations and other system parameters are summarized in the Process Flow Chart (Appendix A). The moisture separator is equipped with a probe-controlled pump which directs accumulated fluids to the ground-water treatment system's oil/water separator (see Section 5.2.3). If the water level in the moisture separator reaches a high-level fault, or if differential pressures build up in the in-line filter or the blower, the blower will deactivate and shut down both vapor extraction systems and the bioventing injection system. Bioventing injection air will be supplied by a regenerative blower equipped with an inlet particulate filter. The injection blower will be deactivated if differential pressure builds up at the inlet filter or at the blower discharge. For safety and fire code regulations, the vapor treatment system will be housed in its own portion of the treatment enclosure (see Treatment System Trailer, Sheet T-4).

Vapor treatment will be provided by a catalytic oxidizer (cat-ox; ThermTech-brand, Model #VAC-25) which will discharge to the atmosphere in accordance with DPNR regulations. For safety and fire code regulations, the cat-ox will not be housed within the treatment system trailer. The cat-ox unit will be supplied with supplemental propane to maintain the proper operational temperature for maximum contaminant destruction efficiency. The cat-ox unit will deactivate, and the vapor extraction system (and bioventing injection) will turn off, if the unit is not operating within the proper temperature range, or if influent pressure falls below pre-set levels. The remedial system's telephone dial-out feature will be configured to notify the operator whenever the system is deactivated. Additional details on the fault controls for Remedial Work Element I are provided in the O&M Manual and Sheet T-6.

5.1.4 Remedial Work Element I - System Component Capacities

The design air flow for each of the SVE wells is 15 to 20 cfm at 20 wc, and the design air flow for each of the five bioventing extraction wells is 3 to 5 cfm at 20 inches wc, for a total estimated operational vapor extraction air flow of 90 to 125 cfm. The regenerative blower which will be used for the vapor system has a capacity of approximately 190 cfm at 20 inches wc (a pump curve for the blower is provided in Appendix A), which is an additional capacity of at least 65 cfm greater than the maximum design flow at the operating vacuum. This additional capacity should be more than adequate to address potential expansion of the vapor extraction system, if required, as various SVE and bioventing extraction wells will be taken "off-line" when asymptotic contaminant mass recovery conditions are reached at individual wells. However, if necessary, the catalytic oxidizer has a maximum capacity of approximately 225 cfm; an additional blower could be incorporated into the system to reach the maximum capacity of the catalytic oxidizer, which would provide at least 100 cfm of additional air flow capacity.

The design air flow for each of the five bioventing injection wells is 3 to 5 cfm for a total estimated operational injection air flow of 15 to 25 cfm. The bioventing injection blower has a capacity of approximately 50 to 60 cfm, which will allow a 100% increase in injection air flow rates.

As discussed in Section 4.1.4, the cat-ox unit, which has a minimum treatment efficiency of at least 95%, can effectively process higher or lower than expected contaminant concentrations by increasing or decreasing the rate of supplemental propane consumption without any loss of treatment removal efficiency. As discussed above, the cat-ox unit has a maximum air flow capacity of 225 cfm which is greater than other system components currently incorporated into Remedial Work Element I.

More detailed information on system components and overall system operation can be found in the Project Manual/Technical Specifications and the O&M Manual. Manufacturers cut sheets for all system equipment are also included in the O&M Manual.

5.2 Remedial Work Element II (Ground-Water Remediation)

System components for Remedial Work Element II (Ground-Water Remediation) include: 1) four shallow extraction wells with pumping rates of approximately 0.25 to 0.50 gpm per well; 2) four deep extraction wells with pumping rates of approximately 0.50 to 1.0 gpm per well; 3) an individual well piping system connecting the wells to the treatment enclosure; 4) an oil/water separator, filter, equalization/holding tank, and chemical feed system (sequestering agent) for pretreatment of recovered fluids; and 5) treatment of recovered water via air stripper and two GAC vessels.

5.2.1 Remedial Work Element II - Wells

The four shallow extraction wells (G1, G2, G3, G4) installed proximal to the north oil/water separator (Figure 3-1) have been installed to a depth of 15 feet below grade. Well construction details include the following (see Table 3-1 and Sheet G-7):

- 4-inch diameter well casing and screen (PVC);
- 10 feet of 0.01 slot well screen, placed at depths of 5 feet below grade to the well bottom;
- 5 feet of well riser placed from ground surface to a depth of approximately 5 feet below grade; and,
- completion of a well vault flush with the surrounding grade.

Due to the shallow depth at which the wells are installed, as well as the anticipated short duration of the perched water extraction program, it has been concluded that PVC well pipe, and not stainless steel, be used for well construction.

Four deep extraction wells (G5, G6, G7, G8) were installed to a depth of 60 feet. Three of the four extraction wells (G6, G7, and G8 - approximately 80 feet south of the property line) were installed near the downgradient border of the Esso Tutu Service Station, while the fourth well (G5) was placed proximal to the dispenser island (see Figure 3-1). Well construction details include the following (see Table 3-1 and Sheet G-7):

- 6-inch diameter well casing and screen (stainless steel);
- 45 feet of 0.01 slot well screen, placed at depths of 15 feet below grade to the well bottom;
- 15 feet of well riser placed from ground surface to a depth of approximately 15 feet below grade; and,
- completion of a well vault flush with the surrounding grade.

Despite the fact these recovery wells were completed as bedrock wells, the shallow portions of the bedrock formation are not competent and the wells were not completed as open borehole wells.

Each well will contain a dedicated pneumatic pump connected via individual piping to the treatment system, located in the northwestern portion of the station property. Ground-water extraction wells in the perched water-bearing zone will utilize 1.75"-diameter pumps with a maximum sustainable pumping rate of 1.0 gpm, and extraction wells in the shallow portion of the Tutu aquifer will utilize 3.5"-diameter pumps with a maximum sustainable pumping rate of 3.5 gpm. Compressed air will be delivered from a compressor housed in the ground-water treatment system enclosure via individual piping and vented at the wellheads. Each pneumatic pump is equipped with an air regulator so that pumping rates can be regulated at individual extraction wells and adjusted as necessary to meet the design criteria.

Pneumatic pumps provide maximum efficiency under low flow conditions and are considered ideal for applications where there is slow recharge. The pump is only activated after an internal bladder float indicates that there is sufficient borehole water volume for a complete pumping cycle. The use of pneumatic pumps also eliminates the necessity of running electrical power to each wellhead and constructing each wellhead as an explosion-proof work area. Each extraction well line will be equipped with an in-line flowmeter and sample port to monitor individual ground-water extraction and contaminant mass removal rates.

Extracted fluids will be transferred via individual piping (PVC hose) from each recovery well. All recovery lines will be enclosed by secondary containment lines (4-inch diameter PVC pipe), which will drain into water-tight "pulling stations". The entire piping system will be placed below grade. Wellhead connections are shown on Sheet M-2.

5.2.2 Remedial Work Element II - Piping System

Ground water extracted from both the perched water-bearing zone and shallow aquifer will be transferred to the on-site treatment system according to the schematic presented in Figure 3-1. For ease of operation, it has been decided that individual piping systems will transfer fluids recovered from each extraction well. Extracted ground water will be transferred via individual 0.5-inch diameter piping (PVC hose). Each recovery line (and compressed air line) will be enclosed within secondary containment (4-inch diameter PVC pipe) extending from the wellhead to the treatment area. Intermediate, fluid-tight pull stations will house piping connections, provide locations for secondary containment inspection, and allow drainage slopes to be maintained to the treatment system. Detailed engineering design plans for piping and trenching runs are provided on Sheets M-1 and M-3.

Total fluids recovered from each extraction well will be directed to a treatment building (40-foot long shipping container) installed in the northwest corner of the Esso Tutu Service Station. Individual extraction lines will be manifolded upon entry to the treatment enclosure.

5.2.3 Remedial Work Element II - Treatment System Layout and Controls

The treatment building will be partitioned into rated (explosion-proof) and non-rated areas. All equipment in the rated portion of the building will be manufacturer-certified as explosion-proof. Extracted fluids will be transferred to a manifold at the treatment area and directed through an oil/water separator (OWS) for gravimetric separation of any PSH that has been extracted as part of total fluids pumping. Ground-water extraction system flow pathways are summarized on the Process Flow Diagram (Sheet T-2) and flow concentrations and other system parameters are summarized in the Process Flow Chart (Appendix A). Fluids which have accumulated in the vapor extraction moisture separator (see Section 5.1.3) will also be directed to the OWS. The aqueous phase effluent from the separator will be treated as discussed below.

A decanting valve allows recovered PSH to flow from the OWS to a 55-gallon capacity PSH holding tank equipped with a high-level fault which deactivates the ground-water recovery system when the PSH holding tank is full. The remedial system's telephone dial-out feature will be configured to notify the operator whenever the system is deactivated due to this control fault or other system control faults discussed below. Additional details on this fault control and other system fault controls which are part of the ground-water extraction system can be found on the Control Logic Diagram (Sheet T-6) and in the O&M Manual. PSH accumulated through the separation process, as well as through manual bailing efforts, will be disposed at an off-site location, to be determined subsequent to waste characterization analysis.

Gravity will direct process flow water from the OWS to a 500-gallon holding tank. A sequestering agent, designed to prevent iron and manganese precipitation from fouling the air stripper, will also be added to the holding tank. The sequestering agent will be hydrated in an 85-gallon capacity, chemical-holding tank equipped with a mixer. A calibrated dose of the sequestering agent will be directed to the holding tank by a metering pump.

Process water from the holding tank is directed by a centrifugal transfer pump through a pre-stripper filter. The filter will remove suspended sediments recovered by the total fluids pumps. The filter is equipped with a differential pressure switch that will deactivate the transfer pump and the air stripper if the filter becomes clogged (differential pressure exceeds 15 psi). Process water is then directed to a shallow tray, low profile air stripper for treatment.

Process water will enter the top of the air stripper and cascade down via gravity through a series of four trays equipped with aerators. The air stripper is equipped with a 300 scfm blower that will pull in ambient outside and indoor air from the treatment enclosure (to remove any fugitive indoor vapors) through an in-line filter/silencer and force the air upwards through the trays. The forced air causes volatilization of contaminants in the process water; volatilized compounds from the process water enter the process air stream and are discharged to the atmosphere in accordance with DPNR Air Pollution Control Permit regulations (Section 8.0). Process water accumulates in an air stripper sump and is removed from the air stripper by a transfer pump that is activated/deactivated by a pair of level probes.

The air stripper sump is equipped with a high level fault that will deactivate the ground-water recovery system if water accumulates in the sump. The air stripper and the air filter are equipped with air flow switches which will deactivate the ground-water extraction pumps if insufficient air flow is moving through the air stripper. This insures that water will not flow through the system unless it is undergoing proper treatment.

Process water from the air stripper is directed by a centrifugal transfer pump through an in-line filter bank. The two filters, which are present to remove finer particles (including precipitated iron from the air stripper) which could lower the performance of the downflow GAC vessels, are arranged in parallel to allow continued operation of the treatment system if one filter becomes clogged (and during filter changeouts). The filter bank is equipped with a differential pressure switch similar to the pre-stripper filter that will turn off the transfer pump if both filters become clogged (differential pressure exceeds 15 psi).

After passing through the filter bank, process water receives final "polish" via two, 55-gallon capacity (200 pounds of carbon) GAC vessels arranged in series. Although design calculations (Section 4.2.4) indicate that no secondary treatment (GAC) is required, the GAC vessels are incorporated into the treatment system as a precautionary measure. The GAC vessels will be equipped with appropriate valving and sample ports to allow unconstrained carbon changeouts and compliance sampling. If the primary GAC is receiving excess pressure (more than 15 psi), a pressure relief valve will direct process water away from the primary GAC and back to the air stripper sump, and a differential pressure switch will turn off the transfer pump. Subsequent to treatment, effluent water will be discharged to the storm sewer in Four Winds Plaza (Turpentine Run) in accordance with Esso's TPDES Permit #VI00040703 (Section 8.0).

5.2.4 Remedial Work Element II - System Component Capacities

The 1.75"-diameter shallow extraction well pneumatic pumps have a maximum sustainable pumping rate of 1.0 gpm providing at least 100% additional capacity compared with the expected flow rates of 0.25 to 0.50 gpm per well. Similarly, the 3"-diameter deep extraction well pneumatic pumps have a maximum sustainable pumping rate of 3.5 gpm providing at least 100% additional capacity compared with the expected flow rates of 0.50 to 1.0 gpm per well. Although it is considered very unlikely that long term pumping rates will exceed the maximum pump capacity, contingencies for higher well yields were previously discussed in Section 4.2.1.

Based on air stripper emission calculations and DPNR air discharge limits discussed in Section 4.2.4, the treatment system is designed to operate and provide effective treatment at sustained flows of 12 gpm, providing approximately 100% additional capacity under conditions expected during the first year of operation (predicted average sustained flow rate of 6 gpm). If necessary, the system can operate within performance standards at peak flows of 15 gpm for short intervals, providing an additional safety factor. After a period of 6 to 12 months of continued system operation (and subsequent dewatering of the perched water zone), recovery rates from the four perched water wells will be reduced or negligible, and continued pumping will also result in declining dissolved VOC concentrations over time, thereby adding additional potential capacity/safety factor to the ground-water recovery system.

The OWS, centrifugal transfer pumps, filter housing, particulate filters, GAC vessels, and other Remedial Work Element II system components can all operate at sustained flow rates of 12 gpm and peak flows of 15 gpm (or greater). Technical specifications for these components are provided in the Project Manual/Technical Specifications and the O&M Manual.

SECTION 6.0

SOURCE CONTROL PLAN PERFORMANCE CRITERIA

This section describes the general performance criteria and confirmatory sampling and monitoring that will be used to evaluate the effectiveness and ability of the Source Control Plan to meet the Design Objectives as outlined in Section 3.0. The section also discusses general performance contingencies (for specific equipment and operational contingencies see Section 5.0), and provides information on the sampling and monitoring that will be used to evaluate the performance of Remedial Work Elements I and II. Specific details on sampling and monitoring methods, frequency, and other aspects of protocol are found in the accompanying O&M Manual.

6.1 Performance Criteria - Remedial Work Element I (Soil)

Remedial activities associated with Remedial Work Element I will consist of SVE system operation and bioventing. SVE will be performed concurrently with dewatering of the perched water-bearing zone (and PSH removal). Bioventing remedial activities will be performed subsequent to dehydration of the perched water zone. Details on the remedial activities to be performed in conjunction with Remedial Work Element I are provided in Section 3.3.

System monitoring will be performed throughout the duration of soil remedial activities to: 1) ensure technology effectiveness; 2) monitor contaminant mass removal; and 3) confirm vapor capture areas. Performance monitoring activities for the SVE and bioventing systems will include: 1) the collection of vapor samples to quantify the total mass of hydrocarbons removed; 2) the measurement of vacuum levels at extraction wells and vapor monitoring points to determine the effective radii of influence; 3) the collection of water levels to confirm dewatering of the perched water zone (necessary for initiation of bioventing); 4) the collection of vapor samples to confirm bioventing effectiveness; and 5) vapor treatment off-gas monitoring. Sampling protocol and other monitoring activities associated with the SVE/bioventing system are outlined in the O&M Manual.

Vapor samples will be collected from individual SVE wells to determine contaminant mass removal. It is expected that after a continued period of SVE operation, total contaminant mass removal, or residual concentrations in soils (as measured indirectly through vapor monitoring), will exhibit minimal change, and begin to approach an asymptotic limit of mass or concentration. Once the asymptotic limit is reached via SVE, bioventing will be initiated in the area of the north oil/water separator. Continued bioventing activity in this area will also subsequently reach a secondary, albeit lower, asymptotic limit.

Each SVE well is equipped with a vacuum gauge to measure applied vacuum at the wellhead. Vapor monitoring points (VMPs) in the vicinity of the SVE wells will periodically be fitted with a well seal and vacuum gauge to measure the induced vacuum at the VMP. Figure 3-2 depicts the predicted radii of influence for the SVE system based on pilot testing data. Analysis of the induced vacuum data collected during remedial system operation will provide the actual radius of influence for each SVE well under field conditions. Based on these data, the applied vacuum at individual SVE wells will be adjusted (via valving at each wellhead) to maximize/optimize contaminant mass removal from each SVE well.

Initiation of bioventing in the area proximal to the north oil/water separator is predicated on the dewatering of the perched water table. Data collected from the weekly liquid level measurements obtained during the first year of system operation will be used to determine when the perched zone has been dewatered and operation of the bioventing system can begin.

The bioventing system will consist of a series of injection and extraction wells. In the subsurface, the concentration of oxygen is often the most important limiting factor on biodegradation. The injection of ambient air (containing approximately 20.8% oxygen) via the bioventing system should stimulate microbial activity and associated biodegradation. The bioventing extraction wells will help to convey and distribute the injected air from the injection well, and exhaust the oxygen-depleted air and biodegradation byproducts, such as carbon dioxide.

Once the bioventing system is operational, vapor samples will be collected from individual bioventing extraction wells and screened for oxygen, carbon dioxide, and methane concentrations. VMPs can also be monitored for the same gases to determine the area of bioventing influence. Increasing oxygen levels (and decreasing carbon dioxide and methane concentrations) over time will indicate bioventing system effectiveness. Hydrocarbon biodegradation rates can be quantified using stochiometric equations (developed in Hinchee, et al, 1992) which incorporate oxygen utilization rates (and/or carbon dioxide production).

During operation of the SVE/bioventing systems, extracted vapors will be treated via catalytic oxidation. Vapor samples will be collected from the system influent manifold and the catalytic oxidizer effluent to determine the effectiveness of the catalyst and to ensure compliance with all discharge requirements.

To the extent practical, the site-specific SSLs established by the ROD will be the target contaminant clean-up concentrations for Remedial Work Element I. As discussed above, contaminant levels will reach an asymptotic limit after continued operation of the SVE/bioventing systems. Although Remedial Work Element I is expected to achieve significant soil contaminant mass removal, the final asymptotic limit for a given compound (and its relationship to the corresponding SSL) cannot be determined with certainty until actual operation of the remedial system.

Data collected from the SVE/bioventing monitoring program will be used to calculate the removal of petroleum mass from the subsurface and determine the schedule for system shut down. Once site data indicate that the hydrocarbon concentrations have reached an asymptote, confirmation soil sampling will be implemented adjacent to and south of the north oil/water separator, in the vicinity of the dispenser island, and downgradient from the UST tank field.

The confirmation sampling program will include two borings drilled adjacent to the north oil/water separator, three borings drilled south of the separator in the alleyway, and two borings drilled south of the dispenser island. One soil sample will be obtained from each boring, at the interval which demonstrates the greatest petroleum impact. Sample selection will also be based upon field criteria; specifically, photoionization detector (PID) readings, visual and olfactory observations, and depth. Soil confirmation samples will be analyzed for volatile organic compounds by EPA Method 8240, polycyclic aromatic hydrocarbons by Method 8310, and petroleum hydrocarbons (e.g., gasoline- and diesel-range organics) by Gas Chromatography, EPA Method 8015A.

Analytical data obtained during the confirmation program will be compared to the site-specific SSLs. If the data indicate that soil contaminant concentrations achieved via Remedial Work Element I are reduced to less than the site-specific SSLs, a request will be submitted to EPA for approval to terminate soil remediation activities. Should asymptotic levels remain above the SSLs, EPA/DPNR will be notified and Remedial Work Element I Contingency Measures described below in Section 6.2 will be invoked. A complete analysis of the remedial system's performance, the effectiveness of the Contingency Measures, and an evaluation of all applicable alternate technologies will be prepared and submitted to EPA/DPNR for review, if the original Performance Standards cannot be achieved for Remedial Work Element I.

6.2 Contingency Measures - Remedial Work Element I (Soil)

As discussed above, the Source Control Program (SCP) at the Esso Tutu Service Station will utilize SVE and bioventing remedial technologies during the execution of Remedial Work Element I. The SCP has been formulated based upon existing site empirical data and best professional judgment, and is consistent, to the extent possible, with the Tutu Well field ROD. Certain efforts will be instituted to monitor the effectiveness of the remedial program and to identify problems as they arise. Specifically, the following contingencies will be evaluated/implemented pending on-site developments:

1. <u>Inability to Reduce Contaminant Mass - Vadose Zone</u>
   The vadose zone remedial program will incorporate bioventing and SVE to reduce contaminant mass. Although vadose zone modeling indicates that existing soil concentrations are protective of ground-water MCLs, remedial efforts are proposed to remove contaminant mass in areas which may not have been fully investigated or which may have been associated with a measurable quantity of PSH. As part of these efforts, certain assumptions have been incorporated in the layout of bioventing and SVE wells to recover a majority of the contaminant mass.

   Collection and analysis of extraction well vapor samples, quantitative analysis of soil samples, and field monitoring of subsurface air pressure/vacuum will be performed to evaluate contaminant mass removal from the vadose zone, and determine SVE well radii of influence (see Section 6.1). Should these data indicate that remedial efforts are not effectively reducing contaminant concentrations, or that insufficient radii of influence are being produced, alternative measures will be considered. These measures could include: installation of additional SVE/bioventing wells or passive venting points to increase the areal extent of system influence, soil excavation/disposal, and other potentially applicable technologies such as enhanced bioremediation. The discussion to implement any/all of these measures will made after a completion evaluation of the data and discussions with EPA/DPNR.

2. <u>Inability to Dewater Perched Zone</u>
   The dewatering program for the perched water-bearing zone is based upon the assumption that the source of water is identified and mitigated. At present, the most likely source of water is considered to be the station cistern and/or infiltration of storm water beneath the station building. In conjunction with implementation of the dewatering program, the source of water will be confirmed and mitigated.

Implementation of bioventing in the area proximal to the north oil/water separator is predicated on the ability to remove most, if not all, water present in the perched zone. The monitoring programs in this area will include the collection of water level data to determine the system's effectiveness in dewatering this area. If the perched zone cannot be dewatered utilizing the existing system, an alternate program will be developed to reduce contaminant mass in this area. Potential alternatives could include simultaneous operation of fluid extraction and bioventing systems, installation of additional dewatering wells, and soil excavation/disposal.

3. <u>Excessive Recovery of Ground Water/Moisture through SVE Wells</u>
During SVE activities, small amounts of ground water or moisture may be introduced into the recovery system via direct entrainment from the extraction well or condensation. The SVE system is equipped with moisture knockout standpipes along the main piping manifold and a 30-gallon capacity moisture separation tank for fluid collection and treatment; however, if excessive water is being introduced to the SVE system, the following measures will be taken: 1) vacuum will be temporarily lowered at individual extraction wells, thereby reducing air flow, ground-water levels within the wells due to mounding, and associated water recovery; 2) vapor extraction at individual wells may be temporarily turned off, or in the case of SVE wells located within the perched water zone, delayed until the perched zone is dewatered; and 3) if warranted by conditions, ancillary ground-water extraction from SVE wells via pumping will be evaluated.

4. <u>Exceedance of Air Emission Discharge Limits</u>
Compliance monitoring will be implemented to ensure that discharge requirements are satisfied. The program for confirming compliance will be consistent with specifications stipulated in the Air Pollution Control Permit issued by DPNR (see Section 8.0). SVE/bioventing vapor treatment will be provided by catalytic oxidation. This technology is normally an extremely effective means of contaminant removal and destruction, and it is also possible that vapor concentrations generated over time will decline to concentrations that will not require treatment. However, should compliance samples indicate that air emissions exceed applicable limitations, modifications to the existing treatment program will be developed. These modifications could include replacement of the existing catalyst and/or installation of additional catalyst units to provide higher treatment efficiencies. These measures will be implemented as necessary to ensure that the operation of the SVE/bioventing system complies with all EPA/DPNR discharge requirements.

If any of the above concerns develop during the course of the SCP, EPA/DPNR will be notified and included in discussions related to evaluation and selection of alternative programs. As discussed above, many of the contingency issues are predicated on the collection of site monitoring and compliance data. The compliance monitoring program that will be implemented as part of the Esso SCP is summarized in the O&M Manual.

6.3 Performance Criteria - Remedial Work Element II (Ground Water)

System monitoring will be performed throughout the duration of ground-water remedial efforts to ensure system effectiveness and to evaluate performance criteria. Specifically, the monitoring program will be utilized to: 1) confirm dissolved mass removal in the source area; 2) confirm the absence of plume expansion within the shallow bedrock aquifer beneath the station; 3) ensure sufficient hydraulic capture along the southern boundary of the Esso Tutu Service Station; and 4) monitor PSH removal effort.

Performance monitoring activities for the ground-water extraction system will include: 1) collection of ground-water quality samples from the system to quantify the total mass of hydrocarbons removed; 2) collection of ground-water quality samples from individual recovery/monitoring wells to monitor the spatial distribution of the contaminant plume; 3) measurement of liquid levels at extraction wells and monitoring points to determine the effective radii of influence; 4) collection of liquid levels to confirm dewatering of the perched water zone and removal of PSH; and 5) treated ground water and air stripper off-gas monitoring. Sampling protocol and other monitoring activities associated with the ground-water extraction system are outlined in the O&M Manual.

Ground-water quality samples will be collected from system influent to calculate contaminant mass removal. Ground-water quality samples will also be collected from individual recovery/monitoring wells within the contaminant plume to track the areal extent and magnitude of the plume. Additional details on sampling associated with the ground-water extraction system are outlined in the O&M Manual.

Ground-water quality data will be used to determine system effectiveness. It is expected that after a continued period of ground-water extraction, the system's total contaminant mass removal (and individual well contaminant concentrations) will exhibit minimal change, and begin to approach an asymptotic limit of mass or concentration. Once the asymptotic limit is reached, termination of Remedial Work Element II will be evaluated (see below).

Weekly liquid-level data will be collected from all on-site and proximal wells during the first year of ground-water extraction. This data will be used to calculate the radius of influence for each extraction well and the system's overall capture zone. Figures 4-2 and 4-3 depict the predicted capture zones for the ground-water system based on pilot testing data (Section 4.2.2). Analysis of the liquid-level data collected during remedial system operation will provide the actual area of hydraulic control for each ground-water extraction well under field conditions. Based on these data, pumping depths/rates at individual ground-water extraction wells will be adjusted, if necessary, to ensure sufficient hydraulic capture along the southern boundary of the Esso Tutu Service Station and prevent plume expansion within the shallow bedrock aquifer beneath the station.

Effective treatment of the perched water zone is predicated on the dewatering of the perched water table. Data collected from the weekly liquid level measurements will be used to determine the effectiveness of the dewatering effort.

System monitoring will be performed throughout the duration of the PSH recovery program to ensure system effectiveness. The PSH recovery program will be terminated when free product thicknesses are consistently less than 0.05 feet in all on-site and proximal wells for a period of 12 consecutive months.

During the operation of Remedial Work Element II, total fluids extracted by the system will be processed through an oil/water separator and treated via air stripping. Water samples will be collected before and after air stripper treatment, and air stripper off-gas samples will be collected, to ensure system effectiveness and compliance with all discharge requirements.

Although the air stripper has been sized and designed so that processed water will meet all discharge requirements, as a precautionary measure the treated water will also be directed through primary and secondary granular activated carbon (GAC) vessels, which will provide a final "polish". Water samples will be collected from primary GAC effluent (mid-GAC) on a periodic basis to monitor GAC loading. Monthly water samples will be collected from secondary GAC effluent (final discharge) for TPDES compliance monitoring.

Data collected from the monitoring program will be used to determine the schedule for system shut down. Liquid-level data and ground-water quality data will be obtained throughout implementation of the SCP, estimated to last for a minimum of 5 years. These data will be utilized to confirm the absence of plume expansion, and document hydraulic capture and mass removal.

Termination of Remedial Work Element II efforts in the shallow bedrock aquifer beneath and downgradient of the Esso Tutu Service Station will be based upon compliance with Federal MCLs to the extent practical, or the observation of asymptotic concentrations. As discussed in association with Remedial Work Element I, dissolved contaminant levels will reach an asymptotic limit after continued operation of the ground-water extraction system. Although Remedial Work Element II is expected to achieve significant PSH and dissolved contaminant mass removal, the final asymptotic limit for a given compound (and its relationship to the corresponding SSL) cannot be determined with certainty until actual operation of the remedial system.

Data collected from the ground-water monitoring program will be used to calculate the removal of petroleum mass from the subsurface and determine the schedule for system shut down. Once site data indicate that the hydrocarbon concentrations have reached an asymptote, analytical data obtained during the monitoring program will be compared to the MCLs. If the data indicate that ground-water contaminant concentrations achieved via Remedial Work Element II are reduced to less than the MCLs, a request will be submitted to EPA for approval to terminate ground-water remedial activities. As stated in the UAO, subsequent to achieving these standards, three annual confirmatory sampling events will be performed. Details on the confirmatory sampling are provided in the Post-Remediation Sampling Plan included in the O&M Manual.

Should asymptotic levels remain above the MCLs, EPA/DPNR will be notified and Remedial Work Element II Contingency Measures described below in Section 6.4 will be invoked. A complete analysis of the remedial system's performance, the effectiveness of the Contingency Measures, and an evaluation of all applicable alternate technologies, will be prepared and submitted to EPA/DPNR for review, if the original Performance Standards cannot be achieved for Remedial Work Element II.

6.4 Contingency Measures - Remedial Work Element II (Ground Water)

As discussed above, the SCP at the Esso Tutu Service Station will incorporate PSH recovery and ground-water extraction. This SCP has been formulated based upon existing site empirical data and best professional judgment, and is consistent, to the extent possible, with the Tutu Well field ROD. Certain efforts will be instituted to monitor the effectiveness of the remedial program and to identify problems as they arise. Specifically, the following contingencies will be evaluated/implemented pending on-site developments:

1. Insufficient Radius of Influence - Hydraulic Control
   The ground-water recovery system associated with the shallow aquifer consists of a hydraulic control portion designed to arrest plume expansion. Achievement of sufficient hydraulic capture from each of the four downgradient wells will be monitored through the collection of ground-water elevation measurements and ground-water quality data, as discussed in Section 6.3.

Although it is unexpected, if site data indicate that insufficient capture is being generated due to higher well yields than expected, pump upgrades will be evaluated. If site data indicate that insufficient capture is being generated due to other factors which may limit radii of influence (hydraulic conductivity, aquifer heterogeneity, etc.), and plume expansion is occurring, the need for additional extraction wells will be evaluated.

2. Inability to Dewater Perched Zone
   The dewatering program for the perched water-bearing zone is based upon the assumption that the source of water is identified and mitigated. At present, the source of water is most likely the station cistern and/or storm water infiltration to the subsurface beneath the station building. In conjunction with the dewatering program, the source of water will be confirmed and mitigated.

   If the perched zone cannot be dewatered utilizing the existing system, an alternate program will be developed to reduce PSH and dissolved contaminant mass in this area. Potential alternatives could include installation of additional dewatering wells, simultaneous operation of fluid extraction and bioventing systems, enhanced bioremediation, and soil excavation/disposal.

3. Occurrence of Phase-Separated Hydrocarbons
   Current site data indicate that PSH is periodically present at wells SW-3, SW-7, and CHT-3. Remedial measures outlined above have been designed to address the presence of free product at these locations. Concurrent with, and subsequent to completion of phase-separated hydrocarbon activities, well gauging efforts will be performed to determine the presence/absence of free product at all on-site and proximal monitoring wells. Should free-product reappear in SW-3, SW-7 or CHT-3 (or be discovered in any on-site or proximal monitoring well) at apparent thicknesses greater than 0.05 feet subsequent to termination of recovery activities, PSH removal will be re-instituted. If necessary, the use of automated PSH pumps will also be evaluated.

4. Exceedance of TPDES Discharge Limits
   Compliance monitoring will be implemented to ensure that treated ground-water discharge requirements are satisfied. The program for confirming compliance will be consistent with specifications stipulated in the TPDES permit (see Section 8.0). Should compliance sampling indicate that contaminant levels in treated ground water exceed applicable discharge limitations, modifications to the existing treatment program will be developed. These modifications may include: the incorporation of additional GAC capacity, upgrades to promote air stripper efficiency, or stimulation of pre-stripper volatilization via venturi agitation or similar devices. Appropriate measures will be developed to ensure Remedial Work Element II is in compliance with all discharge requirements.

5. Exceedance of Air Stripper Off-Gas Limits
   Compliance monitoring will be implemented to ensure that air discharge requirements are satisfied. The program for confirming compliance will be consistent with specifications stipulated in the DPNR Air Pollution Control permit (see Section 8.0). Should compliance samples indicate that emissions of air stripper off-gas exceed applicable limitations, modifications to the existing treatment program will be developed. These modifications may include treatment of a portion of the air stripper off-gas by routing it through the Remedial Work Element I catalytic oxidizer, adding vapor GAC treatment, or reducing ground-water extraction rates. Appropriate measures will be developed to ensure Remedial Work Element II is in compliance with all discharge requirements.

If any of the above concerns develop during the course of the SCP, EPA/DPNR will be notified and included in discussions related to evaluation and selection of alternative programs. As discussed above, many of the contingency issues are predicated on the collection of site monitoring and compliance for ground-water quality, ground-water elevation, water discharge concentrations, etc. The compliance monitoring program that will be implemented as part of the Esso SCP is summarized in the O&M Manual.

SECTION 7.0

INSTITUTIONAL CONTROLS

The remedy outlined in EPA's August 5, 1996 ROD included institutional controls for the site. The institutional controls are required to: 1) place limitations on property usage and 2) ensure the excavation/disturbance of soil will not occur without a permit. Based on the findings of EPA's Baseline Human Health Risk Assessment, surface soil and subsurface soils were found to pose an acceptable risk to human health for workers under both current conditions and a future use scenario involving workers conducting excavation activities. Presently, the service station property is completely paved and surface soil is not available for contact. The institutional controls will be instituted as follows:

- future property use will be limited to commercial or industrial use only (e.g., not residential);
- excavation, transportation, and usage of soil or rock from impacted areas will not occur without EPA and DPNR approval.

The institutional controls listed above will be implemented by amending the deed to include these restrictions. If the residual levels of the chemicals of concern present in surface and subsurface soils are reduced through implementation of the Source Control Plan, and thereby pose no significant risk to human health, safety or the environment, EPA will be petitioned to remove the deed restrictions.

SECTION 8.0

PERMITS

8.1 Construction Permits

Prior to initiation of construction, all construction activities were reviewed with the U.S.V.I. Department of Planning and Natural Resources to determine appropriate permitting requirements. Approval to proceed with construction activities has been received; however, a copy of the final permitting package, which includes an earth change permit, is not available at this time.

8.2 Air Pollution Control Permits

Vapor discharges from the SVE Treatment System will initially be regulated under an "Authority to Construct" Permit # STT-755-B-98 issued by DPNR Air Pollution Control. This permit is currently undergoing revision and finalization with DPNR; however, DPNR has provided verbal and written authorization to proceed with construction until the final permit is issued (Appendix B). Details on sampling/monitoring associated with compliance monitoring of the vapor extraction system are summarized in the O&M Manual. A copy of the revised permit submission is included in Appendix B.

Vapor discharges from the ground-water remedial system will be regulated under the DPNR "Authority to Construct" Air Pollution Control Permit # STT-755-A-98. This permit is currently undergoing revision and finalization with DPNR; however, DPNR has provided verbal and written authorization to proceed with construction until the final permit is issued (Appendix B). Compliance sampling/monitoring associated with the Ground-Water Treatment system, will consist of influent and effluent samples water samples from the air stripper which will be analyzed for target compounds identified in the Air Pollution Control Permit. The analytical data will be used to calculate total contaminant mass discharged. Additional details on sampling/monitoring associated with compliance monitoring of the ground-water extraction system are summarized in the O&M Manual. A copy of the revised permit submission is included in Appendix B.

8.3 Ground-Water Discharge Permits

Treated aqueous-phase discharges from the ground-water remedial system (i.e., post-carbon treatment) will be regulated under TPDES Permit #VI00040703 issued by DPNR. Effluent water will be discharged to the storm sewer in Four Winds Plaza (Turpentine Run). As specified in the permit, compliance sampling/monitoring will include effluent sampling of BTX, total petroleum hydrocarbons (TPH), total organic carbon (TOC), total suspended solids (TSS), total lead, and pH (see the O&M Manual for details on compliance monitoring). A copy of the TPDES permit is included in Appendix B.

SECTION 9.0

ACCESS AGREEMENTS

Off-site construction activities are limited to well installation (G6 and G8) and associated trenching activities for the remedial system. These activities will be performed on the Four Winds property, located to the south and west of the site. An Access Agreement for these activities was granted by the property owners; a copy of the agreement is included as Appendix C. No properties or easements were acquired as part of the Remedial Action.

SECTION 10.0

CONSTRUCTION QUALITY ASSURANCE PROJECT PLAN

The Construction Quality Assurance Project Plan (CQAPP) will provide quality assurance/quality control during the remedial system construction phase. The CQAPP will be implemented by the Independent Quality Assurance Team (IQAT; final team membership is being finalized at this time). IQAT personnel will be selected based upon knowledge and prior experience in their designated area of responsibility. The names and qualifications of the IQAT will be submitted to EPA for review and approval.

The CQAPP will be directed by a Professional Engineer licensed in the U.S. Virgin Islands (Ravi Korlipara, Ph.D., P.E., Korlipara Engineering; Dr. Korlipara is in the process of acquiring a USVI P.E. license), and by the Site Engineer/Scientist (Chad Stevens, Esso/Robert Zei, FES, and/or a qualified designee technically qualified and knowledgeable about the project) who will be on site during all remedial system construction activities.

All contractors will report directly to the Site Engineer/Scientist who will be authorized to stop any activities which are not in compliance with the CQAPP, applicable environmental and contract requirements, or any activities which endanger the health and safety of construction personnel and surrounding residents. The Site Engineer/Scientist will be responsible for implementation of construction and construction oversight, remedial system construction quality assurance inspections, and testing as discussed below.

10.1 Plan for Implementation of Construction and Construction Oversight

Clear lines of authority will be established for all key personnel involved in the construction phase of remedial system installation. An organizational chart depicting the lines of authority is included as Table 10-1. Responsibilities of all key personnel will be clearly established and communicated to all staff before the start of construction.

The construction phase of work may be broadly classified into four categories: 1) remedial system assembly: 2) well installation; 3) construction associated with remedial system trenching and piping; and 4) on-site remedial treatment system installation. The inspection activities associated with these four phases of construction, including the scope, frequency, and details of inspections and testing are discussed in Sections 10.2 and 10.3, and in the technical specifications referenced therein.

Upon selection of contractors and approval from EPA to proceed with construction, a Notice to Proceed will be issued to the contractors. The contractor will be required to provide: 1) a construction schedule consistent with the overall project schedule; 2) a health and safety plan and proof of proper OSHA training for all on-site workers; 3) quality assurance plans; 4) work plans; and 5) other technical submittals for review by the Site Engineer/Scientist and the IQAT. The Site Engineer/Scientist will oversee construction mobilization. A pre-construction meeting will be held to discuss duties, responsibilities, scope of work, planning, schedule, health and safety issues, and any other construction related issues with all contractors.

The Site Engineer/Scientist and the IQAT will review and approve performance of construction, inspection, and testing (Sections 10.2 and 10.3). The Site Engineer/Scientist will also review and approve shop drawings, any requested field changes (deviations from design plans and specifications), any other changes from plans and specifications, preparation of "as-built" drawings (Section 10.2.2), and invoices and progress payments. The Site Engineer/Scientist will be responsible for final inspection and acceptance of all work performed by the contractor.

10.2 Inspection and Certification

The Site Engineer/Scientist will review documentation provided by the on-site contractor(s) to affirm that all construction materials used at the site meet industry and performance guidelines as required in the Remedial Design Project Manual. The Site Engineer/Scientist will conduct daily inspections of all installed piping and trenches to assure compliance with installation specifications established in the engineering construction design drawings. Situations of non-compliance from specifications will be documented in the daily log (see Section 10.2.1) and the appropriate contractor(s) will be notified. Additional work will not proceed until the non-compliance is corrected by the contractor(s). The IQAT will also selectively inspect the work of the contractor.

The remedial treatment system will be assembled off site by Independent Equipment Corporation (IEC) of Raritan, New Jersey. A licensed PE and project engineers (Richard Tobia, Abraham Platt, Paul Fischer) on the IEC project team, and qualified technicians from IEC will inspect and test each component (see Section 10.3) to ensure it meets manufacturer and industry standards. The Site Engineer/Scientist will also inspect the system for proper operation before shipment to the facility. A member of the IEC project team (Paul Fischer) and the Site Engineer/Scientist will reinspect the remedial system after it is installed at the Facility. IEC will provide written certification of the successful completion of inspection and testing of system components to the Site Engineer/Scientist.

During remedial system construction, modifications of the original remedial system design may occur. These deviations may include changes such as field relocations of piping or trenches due to accessibility constraints, changes in piping configuration which improve ease of installation or access, or other changes of a similar nature. Modifications from the original remedial system design will be limited to changes which do not affect ultimate system operation or performance; all changes are subject to the approval of the Site Engineer/Scientist. Any substitutions of materials or parts must equal or better the standards outlined in the technical specifications. Any modifications which are likely to affect system operation or performance will require full review and approval by EPA and DPNR before implementation.

The Professional Engineer will review all documents associated with the CQAPP including daily logs, as-built drawings, testing results, and contractor's certifications. After review and approval of these documents, and inspection and testing of the remedial system, the Professional Engineer will certify that:

1) the Remedial Construction Work has been completed in full satisfaction of the requirements of the 5 August 1996 ROD, the Order, and all approved plans and specifications developed thereunder, including the CQAPP, and

2) the SVE and Ground-Water Extraction/Treatment systems are operating in accordance with approved design and performance criteria.

This Certification of Work will be submitted to EPA/DPNR as part of the Remedial Construction Report.

10.2.1 Daily Logging and Measurements

A daily construction log will be completed and signed by the Site Engineer/Scientist. The daily logs will provide detailed descriptions of all construction activities including:

a) contractors and personnel on site
b) work performed
c) health and safety issues
d) community relations
e) air monitoring
f) daily inspection results
g) photographic documentation
h) soils quantities excavated
i) waste stockpiling and/or disposal
j) testing performed and resultant data

The daily log will also include the dimensions of piping and trenching installed, surveying measurements, and an inventory of materials utilized. Information will be cross-referenced and indicated on a set of engineering construction drawings where appropriate.

Photodocumentation of remedial construction activities will also be prepared on a daily basis. All excavated trenches, trenches with installed piping, well vaults, system pulling stations, piping connections, treatment enclosure, and treatment system components will be photographed with appropriate scaling. Photographs will be recorded in the daily log and photo locations will be keyed on the "as-built" drawings (see below). Select photographs will be included in the Remedial System Construction Report.

10.2.2 "As-Built Drawings" and Logs

During remedial construction, a dedicated set of engineering construction design drawings will be used on site for recording field changes to the original remedial system design. All field changes will have received prior approval from the Site Engineer/Scientist before implementation. The Site Engineer/Scientist will initial and date all such changes on the dedicated engineering construction design drawings. The changes will also be recorded in the daily log (see Section 10.2.1), and photodocumented where appropriate.

The dedicated field construction drawings, daily logs, and photodocuments will be used to generate a set of "as-built" drawings upon completion of remedial system construction. The "as-built drawings" will be signed and stamped by the Professional Engineer and submitted as part of the Remedial Construction Report.

10.3 Testing of Materials, Construction, and Final System

The SVE and Ground-Water Treatment systems will be tested to assure proper performance and compliance with all applicable EPA and DPNR regulations. Additional testing details are provided in the Project Manual. The Site Engineer/Scientist will supervise all on-site quality testing. Equipment/materials testing will occur in four stages:

a) Remedial system assembly - The remedial treatment system will be assembled in New Jersey by IEC. A licensed PE and project engineers (Richard Tobia, Abraham Platt, Paul Fischer) on the IEC project team, and qualified technicians from IEC will inspect and test each component (see Section 10.3) to ensure it meets manufacturer and industry standards, and the technical specifications in the Project Manual which also includes specifications for testing. The Site Engineer/Scientist will also inspect the system for proper operation before shipment to the facility. Each system component will be tested individually and/or in conjunction with other associated system components to assure proper performance of the system before final shipment to the Facility. The remedial system assembly contractor (IEC) will provide written certification of the successful completion of inspection and testing of system components to the Site Engineer/Scientist.

b) Well installation - The drilling subcontractor provided well construction materials which met all relevant industry standards to ensure proper well performance. Wells were installed (and will be developed) according to the protocol presented in the Supplemental Remedial Design Work Plan (draft submittal to EPA/DPNR dated 14 August 1998). A Project Scientist from FES supervised all well installation activities and maintained a detailed daily log which included all pertinent descriptions, boring logs, measurements, and other data associated with the well installations.

c) Construction associated with remedial system trenching and piping - All materials used in association with remedial system trenching and piping installation will meet industry standards and performance guidelines required in the Project Manual. Construction will follow construction and testing procedures as described in the technical specifications of the Project Manual. Installed piping and trenches will be measured/surveyed to assure conformity with installation specifications established in the engineering construction design drawings.

   After installation, each vapor line segment (well to pull station, or pull station to pull station) will be vacuum- or air pressure-tested using standard field methods as described in the Project Manual to ensure that adequate vacuum (or pressure) will be maintained. At a minimum, each PVC extraction line will be capped and subjected to an induced vacuum of 60 inches of water for a period of two hours. Extraction lines which do not maintain an induced vacuum of at least 58 inches of water will be reinstalled.

Each ground-water recovery and pneumatic air line segment will be pressure-tested to 150 pounds per square inch (psi), and required to maintain at least 145 psi for two hours. Alternate methods of line testing, such as helium line leak detection, may be substituted with the approval of the Site Engineer/Scientist.

Test results will be documented and approved by the Site Engineer/Scientist before the corresponding trench segment is backfilled. The IQAT will also selectively conduct independent testing of the work of the contractor.

d) On-site remedial treatment system installation - Qualified technicians from the remedial treatment construction contractor (IEC) will inspect and test all components of the remedial treatment system after shipment and on-site installation to ensure proper operation. Testing will include, but not be limited to, reviewing all faults, probes, safety switches, and logic controls for proper functioning; preliminary operation of all well pumps, transfer pumps, blowers, and motors for performance evaluation; preliminary operation of the air stripper and catalytic oxidizer to ensure proper operational temperatures, air flow, and air processing; and inspecting and testing the complete remedial system for leaks or other breaches of integrity. The IQAT will also selectively conduct independent testing and inspection of the work of the contractor.

   The remedial system construction contractor (IEC) will provide written certification upon successful completion of inspection and testing of the installed remedial system according to the technical specifications in the Project Manual. An accelerated sampling and monitoring compliance schedule (see the O&M Manual) will be followed during system start-up to ensure that the remedial system operates within applicable EPA/DPNR regulations.

10.4 Construction Access Agreements

Well installation and associated trenching activities will be performed on the Four Winds property, located to the south and west of the site. An Access Agreement for these activities was granted by the property owners; a copy of the agreement is included as Appendix C. No properties or easements were acquired as part of the Remedial Action.

10.5 Method of Selection of Construction Contractor(s)

The Remedial Treatment System construction contractors (IEC) were selected based on prior experience with the proposed remedial technologies, ability to fabricate pre-packaged, "turn-key" remedial systems, adequate environmental insurance coverage, proper OSHA training and certification for all on-site workers, and previous Superfund experience.

Bid packages for the trenching and piping installation phase of work were sent to qualified construction firms included on Esso's preferred contractor list and additional local construction firms with equivalent credentials. Selection of the construction contractor was based on a review of the contractor's qualifications to perform the necessary work, previous experience with similar types of construction, equipment and labor availability, and reasonableness of construction schedule and costs. The trenching and piping installation phase of the remedial system installation was awarded to O'Brien Construction of St. Thomas, USVI. The successful bidder was required to provide proof of adequate environmental insurance coverage and proper OSHA training and certification for all on-site personnel. Contractor qualifications are included in Appendix D.

10.6 Final Construction Schedule

A proposed construction implementation schedule is included as Table 10-2. The schedule indicates that off-site assembly of the remedial treatment system will be completed during October-November 1998. On-site remedial system trenching and piping will take place during November-early December 1998. After shipment of the remedial treatment system in early December 1998, final on-site assembly and preliminary testing of the remedial system will take place in December 1998. Following EPA approval of the Initial Testing Program (ITP) Plan, initial testing and start-up of the completed remedial system is anticipated for early 1999.

10.7 Final Construction Cost Estimate

A final construction cost estimate is included as Table 10-3. The total estimated cost of the remedial system construction and installation is $951,000. Please note that this cost estimate does not include expenditures associated with subsequent remedial system operation and monitoring.

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TABLES

Table 2-1
Summary of Analytical Data
North Oil/Water Seperator (1993)
Esso Tutu Service Station
St. Thomas, USVI

Analytical Parameter	Units	SS-1 (9')	SS-3 (3')	SS-4 (3')	SS-5 (3')	SS-6 (5')	SS-7 (5')	SS-8 (7')	SS-9 (3')
Aromatic Hydrocarbons									
Benzene	(mg/Kg)	<1.6	0.88	<0.029	0.029	<0.006	0.16	0.27	<0.006
Toluene	(mg/Kg)	46	53	4.6	6.5	<0.006	33	51	<0.006
Ethylbenzene	(mg/Kg)	12	11	0.99	0.52	<0.006	1.7	11	<0.006
Total Xylenes	(mg/Kg)	80.4	77.4	24.2	29	<0.006	58	78	<0.006
Chlorinated Compounds									
Trichloroethene	(mg/Kg)	<1.6	0.26	<0.029	<0.029	<0.006	<0.029	0.045	<0.006
Tetrachloroethene	(mg/Kg)	<1.6	1.1	0.15	0.13	<0.006	0.52	1.5	<0.006
1,1-Dichloroethane	(mg/Kg)	<1.6	0.56	<0.029	<0.029	<0.006	0.031	0.07	<0.006
1,2-Dichloroethene	(mg/Kg)	<1.6	3.2	<0.029	0.032	<0.006	0.075	0.11	<0.006
1,1,1-Trichloroethane	(mg/Kg)	<1.6	<0.036	<0.029	<0.029	<0.006	0.044	0.058	<0.006
Base-Neutral Compounds									
1,2-Dichlorobenzene	(mg/Kg)	NA	2.8	0.84	<2	<0.38	<0.77	1.4	<0.4
Naphthalene	(mg/Kg)	NA	29	11	22	<0.38	19	23	<0.4
Fluorene	(mg/Kg)	NA	3.4	1.4	2.6	<0.38	1.4	1.6	<0.4
Phenanthrene	(mg/Kg)	NA	9.7	4.5	8.1	<0.38	4.3	6.1	<0.4
Anthracene	(mg/Kg)	NA	<2.4	0.92	<2	<0.38	<0.77	1.2	<0.4
Fluoranthene	(mg/Kg)	NA	3.1	1.2	2.4	<0.38	1.1	1.5	<0.4
Pyrene	(mg/Kg)	NA	15	6.5	9	<0.38	5.7	8	<0.4
Benzo (a) anthracene	(mg/Kg)	NA	5.8	2.3	4.3	<0.38	2.1	2.8	<0.4
Chrysene	(mg/Kg)	NA	5.1	2	3.6	<0.38	1.9	2.4	<0.4
Bis (2-ethylhexyl) phthalate	(mg/Kg)	NA	19	8.3	11	<0.38	6.7	9.2	<0.4
Di-n-octyl phthalate	(mg/Kg)	NA	<2.4	2	<2	<0.38	<0.77	<0.77	0.94
Benzo (b) fluoranthene	(mg/Kg)	NA	6.1	2	3.8	<0.38	2	2.5	<0.4
Benzo (a) pyrene	(mg/Kg)	NA	3.2	0.97	<2	<0.38	0.88	1.1	<0.4
Benzo (ghl) perylene	(mg/Kg)	NA	7.7	1.6	3.4	<0.38	1.4	1.9	<0.4
Petroleum Hydrocarbons									
Gasoline Range	(mg/Kg)	NA	5,000	3,000	3,000	<8	4,000	5,000	<8
Kerosene Range	(mg/Kg)	NA	<4,000	<1,000	<1,000	<8	<1,000	<1,000	<8
Diesel Range	(mg/Kg)	NA	<4,000	<1,000	<1,000	<8	<1,000	<1,000	<8

Notes:
1. NA = not analyzed
2. Volatile organic analysis conducted by EPA Method 8240; base neutrals analyzed by EPA Method 8270;
3. TPH analysis conducted by Method 8015 (GD-FID).
4. mg/Kg = Parts per million.

Table 2-2
Summary of Soil Analytical Data (1996)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Sample Designation	Date	Depth (feet)	Benzene (ug/Kg)	Toluene (ug/Kg)	Ethylbenzene (ug/Kg)	Total Xylenes (ug/Kg)	MTBE (ug/Kg)	Acetone (ug/Kg)	Methylene Chloride (ug/Kg)	Trichloro Ethene (ug/Kg)	Tetrachloro Ethene (ug/Kg)	trans-1,2 Dichloro Ethene (ug/Kg)	cis-1,2 Dichloro Ethene (ug/Kg)	1,1 Dichloro Ethene (ug/Kg)	1,1 Dichloro Ethane (ug/Kg)	1,2 Dichloro Ethane (ug/Kg)	2-Butanone (ug/Kg)	Total Organic Carbon (mg/Kg)	TPH DRO (mg/Kg)	TPH GRO (mg/Kg)
North Oil/Water Separator																				
B-1	9/17/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B-2	9/18/96	5-8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,900	NA	NA
B-5	9/23/96	4-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2410	NA	NA
		6-8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		8-10	<5	<5	30	19 J	<5	45 J	<10	<5	<5	<10	<10	<10	<5	<10	<35	NA	<200*	700*
B-6	9/23/96	4-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3160	NA	NA
		8-10	4 J	<1	<1	6	33	<7	<2	<1	<1	<2	<2	<2	<1	<2	<7	NA	<200*	300 J*
B-7	9/23/96	4-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2830	NA	NA
		8-10	3 J	10	56	35	63	480	<2	<1	<1	<2	<2	<2	<1	<2	<8	NA	<9*	<9*
B-15	9/25/96	4-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2300	NA	NA
		6-8	<1	<1	<1	<1	<1	<8	12	<1	<1	<2	<2	<2	<1	<2	<8	NA	6 J	<200
		10-12	<6	<6	66	26 J	<6	<42	95	<6	<6	<12	<12	<12	<6	<12	<42	NA	1,600	2,000
B-18	9/25/96	4-8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2400	NA	NA
B-19	9/26/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B-20	9/26/96	8-10	<1	1 J	<1	<1	30	45	120	<1	<1	<2	<2	<2	<1	<2	<8	NA	5 J	<200
B-16	9/25/96	4-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2100	NA	NA
		10-12	2 J	4 J	10	21	4 J	75	40	<1	<1	<2	<2	<2	<1	<2	14	NA	2,200	30,000
		14-16	<1	<1	<1	<1	<1	<9	13	<1	<1	<2	<2	<2	<1	<2	25	NA	5 J	2,000
B-17	9/25/96	10-12	<1	1 J	<1	<1	<1	37	81	<1	<1	<2	<2	<2	<1	<2	<8	NA	<5	<0.2
Delivery Line/Dispenser Island																				
B-3	9/20/96	2-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,000	NA	NA
		6-8	<1	<1	4 J	28	220	590	4 J	<1	<1	<2	<2	<2	<1	<2	<8	NA	15	4
		8-10	<5	<5	110	1,000	67	410	<11	<5	<5	<11	<11	<11	<5	<11	<37	NA	37	7
		10-12	<5	<5	90	820	42	390	<11	<5	<5	<11	<11	<11	<5	<11	<38	NA	NA	NA
B-4	9/20/96	4-6	<1	<1	<1	<1	30	360	5 J	<1	<1	<2	<2	<2	<1	<2	<8	1,200	<4	<0.2
B-8	9/24/96	1-3	<1	4 J	1 J	<1	33	210	<2	<1	<1	<2	<2	<2	<1	<2	51	NA	<5	2
		4-6	<1	<1	<1	<1	<1	31	<2	<1	<1	<2	<2	<2	<1	<2	9 J	NA	16	2
B-9	9/24/96	6-8	<1	<1	<1	<1	<1	17 J	<2	<1	<1	<2	<2	<2	<1	<2	<8	NA	6 J	<0.2
B-10	9/24/96	4-6	<1	<1	<1	<1	<1	20 J	<2	<1	<1	<2	<2	<2	<1	<2	<7	NA	<4	<0.1 J
B-11	9/24/96	2-4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,300	NA	NA
		4-6	<1	<1	2 J	<1	1,000	87	<2	<1	<1	<2	<2	<2	<1	<2	27	NA	5 J	0.8 J
		8-10	<1	<1	<1	<1	49	110	<2	<1	<1	<2	<2	<2	<1	<2	14	NA	<4	<0.2
B-12	9/24/96	4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5200	NA	NA
		6-8	<1	3 J	<1	<1	5 J	450	<2	<1	<1	<2	<2	<2	<1	<2	130	NA	20	0.3 J
B-13	9/24/96	4-6	<1	4 J	10	11	170	210	<2	<1	<1	<2	<2	<2	<1	<2	39	NA	8 J	2
		6-8	<1	3 J	33	120	120	150	<2	<1	<1	<2	<2	<2	<1	<2	32	NA	10	7
B-14	9/24/96	6-8	<1	<1	3 J	<1	81	240	4 J	<1	<1	<2	<2	<2	<1	<2	21	NA	6 J	0.8 J
		8-10	6	7	280	24	48	<8	<2	<1	<1	<2	<2	<2	<1	<2	<8	NA	2,100	70
		10-12	280 J	<150	3,600	690 J	1,300	<1000	440 J	<150	<150	<300	<300	<300	<150	<300	<1000	NA	2,000	110
B-21	9/27/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B-22	9/27/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B-23	9/30/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B-24	9/30/96	7-9	<1	<1	8	<1	57	250	<2	<1	<1	<2	<2	<2	<1	<2	<8	NA	14 J	0.06 J
		9-11	280 J	<150	23,000	240 J	440 J	<1000	<290	<150	<150	<290	<290	<290	<150	<290	<1000	NA	810	150

Table 2-2
Summary of Soil Analytical Data (1996)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Sample Designation	Date	Sample Interval (feet)	Naphthalene (ug/Kg)	Acenaphthylene (ug/Kg)	Acenaphthene (ug/Kg)	Fluorene (ug/Kg)	Phenathrene (ug/Kg)	Anthracene (ug/Kg)	Fluoranthene (ug/Kg)	Pyrene (ug/Kg)	Benzo (a) anthracene (ug/Kg)	Chrysene (ug/Kg)	Benzo (b) fluoranthene (ug/Kg)	Benzo (k) fluoranthene (ug/Kg)	Benzo (a) pyrene (ug/Kg)	Dibenzo (a,h) anthracene (ug/Kg)	Benzo (g,h,i) perylene (ug/Kg)	Indeno (1,2,3-cd) pyrene (ug/Kg)
North Oil/Water Separator																		
B-5	9/23/96	8-10	<590	<490	<1800	840 J	580 J	291 J	<16	525 J	130	140 J	<7.3	<6.8	<20	<60	330	57 J
B-6	9/23/96	8-10	318 J	<98	<360	625 J	740	400	<7.8	<41	102	130	103	<3.4	71.9	<30	159	21
B-7	9/23/96	8-10	5660 J	<560	<2100	<1100	2400	1290 J	<18	1240	517	540	286	<110	258	<69	530	105 J
B-15	9/25/96	10-12	1030	<120	<430	230 J	370	172 J	<1.9	213	61.4	68	40.3	12.9	36.2	<26	84	13.3 J
B-16	9/25/96	10-12	<140	<120	<440	53 J	46 J	14.9 J	<4.8	<25	<3.8	<11	<2.1	<34	9	40.6	37	<16
		14-16	<72	<60	<220	<13	<21	<2.1	<240	<50	<9.7	<22	<4.3	<4.1	<12	235	<120	<33
Delivery Line/Dispenser Island																		
B-3	9/20/96	8-10	<63	<52	<190	<12	<18	<1.8	<0.83	<4.4	<0.67	<1.9	<0.37	<0.36	129	<140	<280	74
B-4	9/20/96	4-6	<66	<55	<200	<12	<19	<1.9	<0.87	<4.6	<0.7	2.3 J	<0.39	<0.38	<1.1	<3.3	<11	<3
B-14	9/24/96	8-10	9600 J	<1100	<4200	2820 J	4,100	1700 J	<18	1310 J	447	480 J	470	98.1 J	270	<69	500	117 J
		10-12	13400 J	<1200	<4300	4240 J	6,200	2590 J	<19	2,000	680	790	730	149 J	420	149 J	730	147 J
B-24	9/30/96	9-11	2120	<57	<210	488 J	560	220	<89	<4.8	31.9	50	49.4	<0.79	24	<15	50	9.1 J

Notes:
1. Total organic carbon by EPA Method 415.1 modified.
2. TCL Volatiles by EPA Method 8240
3. PAH's by EPA Method 8310.
4. BTEX by EPA Method 8020A.
5. * = Samples were analyzed for Total Petroleum Hydrocarbons by GC-FID Method 8015B modified.
6. J = Estimated concentration.
7. NA = Not Analyzed.
8. A "<" indicates the method detection limit used for that particular compound.
9. ug/Kg = Parts per billion.
10. mg/Kg = parts per million.
11. DRO = Diesel Range Organics.
12. GRO = Gasoline Range Organics.

Table 2-3
Summary of Site Ground-Water Quality Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Analytical Parameter	Units	SW-1		SW-2			SW-3			SW-7			SW-8		DW-1		CHT-2				CHT-3			
		4/5/94	9/28/96	4/5/94	6/22/94	9/28/96	4/5/94	6/23/94	10/4/96	4/5/94	6/23/94	10/5/96	10/3/96	10/3/963 D	4/7/94	6/3/94	2/27/92	4/11/94	9/8/96	10/4/96	2/27/92	11/17/93	4/11/94	6/1/94
Volatile Organic Compounds																								
Benzene	(ug/L)	3,700	3,100	1,400	550 J	220	12,000	10,000 J	10,000	160	99 J	110	2 J	1 J	<5	<10	<50	5	11	15	26,000	2,200	1,900	1,700
Toluene	(ug/L)	1,800	680	1,800	360 J	140	3,400	3,200 J	96	16	<100	<10	<2	<2	<5	<10	<50	<5	<2	<2	38,000	1,600	<50	180
Ethylbenzene	(ug/L)	2,000	1,800	1,000	<1000	18 J	2,200	4,100 J	2,100	110	<100	78	48	45	<5	<10	120	<5	3 J	4 J	2,400	<25	1,500	1,800
Total Xylenes	(ug/L)	8,100	3,000	4,000	1,800 J	130	10,300	22,000 J	8,000	171	82	36	61	59	<5	<10	<50	<5	1 J	4 J	38,000	1,500	1,153	2,000
MTBE	(ug/L)	42,000	14,000	52,000	35,000 J	2400	110,000	89,000 J	100,000	1600	1,500 J	2,700	150	<2	19	16 J	NA	870	110	130	6,200	13,000	15,000	13,000
TCE	(ug/L)	<250*	<10	<250*	<1000*	8 J	<250*	<1000*	<10	<5	<100	<5	<1	<1	15	10 J	<50	<5	<1	<5	<1,000	<25	<50*	<100*
PCE	(ug/L)	<250*	<10	<250*	<1000*	12 J	<250*	<1000*	<10	<5	<100	<5	<1	<1	62	42 J	<50	<5	<1	<5	<1,000	<25	<50*	<100*
trans 1,2 DCE	(ug/L)	NA	<20	NA		<10	NA		<20	NA		<10	<2	<2			NA	NA	<2	<10	NA	<25	NA	
cis 1,2 DCE	(ug/L)	NA	<20	NA		32	NA		<20	NA		<10	<2	<2			NA	NA	<2	<10	NA	NA	NA	
1,2 DCE (total)	(ug/L)	<250*	NA	<250*	<1000*	NA	<250*	<1000*	<20	<5	<100	<10	NA	NA	130	92 J	NA	6	NA	<10	NA	NA	<50*	<100*
Vinyl Chloride	(ug/L)	<500*	NA	<500*	<1000*	NA	<500*	<1000*	<10	<10	<100	<5	NA	NA	<10	<10	<100	<10	NA	<5	<1,000	<25	<100*	<100*
Acetone	(ug/L)	NA	<60	NA		<30	NA		<60	NA		<30	<6	<8			NA	NA	11 J	<6	NA	NA	NA	
Methylene Chloride	(ug/L)	NA	34 J	NA		12 J	NA		28 J	NA		10 J	<2	<2			<50	NA	<2	<2	<1,000	<25	NA	
Total Petroleum Hydrocarbons																								
Gasoline Range	(mg/L)	120	NA	25	NA	NA	310	NA	NA	6	NA	NA	NA	NA	<0.4	NA	NA	<0.4	NA	NA	NA	NA	69	NA
Kerosene Range	(mg/L)	<4	NA	<4	NA	NA	<40	NA	NA	<4	NA	NA	NA	NA	<0.4	NA	NA	<0.4	NA	NA	NA	NA	<0.4	NA
Diesel/#2 Range	(mg/L)	<4	NA	<4	NA	NA	<40	NA	NA	<4	NA	NA	NA	NA	<0.4	NA	NA	<0.4	NA	NA	NA	NA	<0.4	NA
Total Petroleum Hydrocarbons	(mg/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Polynuclear Aromatic Hydrocarbons																								
Naphthalene	(ug/L)	60	NA	<100	<10	NA	1,300	1,000 J	NA	60	96 J	NA	NA	NA	<10	<10	65	<10	NA	NA	NA	NA	260	310
Fluorene	(ug/L)	<4	NA	<2	<10	NA	40	40 J	NA	<2	4 J	NA	NA	NA	<2	<10	<10	<2	NA	NA	NA	NA	3	6 J
Phenathrene	(ug/L)	4	NA	<2	<10	NA	40	32 J	NA	4	3 J	NA	NA	NA	<2	<10	<10	<2	NA	NA	NA	NA	2	4 J
Anthracene	(ug/L)	1	NA	<1	<10	NA	9	<50	NA	<2	<10	NA	NA	NA	<1	<10	<10	<1	NA	NA	NA	NA	<1	<20
Pyrene	(ug/L)	3	NA	<2	<10	NA	7	8 J	NA	3	2 J	NA	NA	NA	<2	<10	<10	<2	NA	NA	NA	NA	<2	<20
Chrysene	(ug/L)	1	NA	<1	<10	NA	<4	9 J	NA	1	<10	NA	NA	NA	<1	<10	<10	<1	NA	NA	NA	NA	<1	<20
Benzo(a) pyrene	(ug/L)	0.3	NA	<0.2	<10	NA	0.7	<50	NA	0.3	<10	NA	NA	NA	<0.2	<10	<10	<0.2	NA	NA	NA	NA	<0.2	<20
Benzo (g,h,i) perylene	(ug/L)	1.4	NA	<0.5	<10	NA	3	<50	NA	1.4	<10	NA	NA	NA	<0.5	<10	<10	<0.5	NA	NA	NA	NA	<0.5	<20
Benzo (b) fluoranthrene	(ug/L)	<0.6	NA	<0.2	<10	NA	2.1	<50	NA	0.5	<10	NA	NA	NA	<0.2	<10	<10	<0.2	NA	NA	NA	NA	<0.2	<20
General Water Chemistry																								
Total Suspended Solids	(mg/L)	120	NA	NA	/284	NA	2,820	324	NA	260	783	NA	NA	NA	18	<10	NA	NA	NA	NA	NA	NA	NA	12300
Carbon Dioxide	(mg/L)	835	220	1,190	NA	79	1,020	NA	NA	858	NA	NA	94	91	566	NA	NA	623	102	NA	NA	NA	834	NA
Dissolved Oxygen	(mg/L)	7.6	NA	3.2	NA	NA	5.2	NA	NA	<0.2	NA	NA	NA	NA	<0.2	NA	NA	2.1	NA	NA	NA	NA	1	NA
Dissolved Lead	(mg/L)	NA	<0.027	NA	NA	<0.027	NA	NA	NA	NA	NA	NA	<0.0012	0.0034	NA	NA	NA	NA	<0.027	NA	NA	NA	NA	NA

Table 2-3
Summary of Site Ground-Water Quality Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Analytical Parameter	Units	CHT-7D			MW-8				MW-9				MW-9S		MW-10					MW-10D			
		4/11/94	6/2/94	10/1/96	9/29/92	4/7/94	6/3/94	9/28/96	10/7/92	10/7/92 D	4/7/94	10/14/96	10/7/92	9/28/96	10/6/92	4/8/94	4/8/94 D	5/31/94	9/28/96	10/6/92	4/8/94	5/31/94	10/10/96
Volatile Organic Compounds																							
Benzene	(ug/L)	<5	<10	<1	<10	<5	<10	<1	26	28	11	7	16	7	<33	<5	<5	<25	2 J	<50	<5	<10	<1
Toluene	(ug/L)	<5	<10	<1	<10	<5	<10	<2	<10	<10	<0.5	<5	2 J	<2	<33	<5	<5	<25	<2	<50	<5	<10	<1
Ethylbenzene	(ug/L)	<5	<10	<1	<10	<5	<10	<2	19	24	39	<5	5 J	<2	<33	<5	<5	<25	5	<50	<5	<10	<1
Total Xylenes	(ug/L)	<5	<10	<1	<10	<5	<10	<1	2 J	3 J	<5	<5	2 J	<1	<33	<5	<5	<25	<1	<50	<5	<10	<1
MTBE	(ug/L)	14	28 J	4 J	51	10	17 J	7	2,700 D	2,900 D	450	11	2,200 D	120	660	420	430	340 J	34	780	130	170 J	22
TCE	(ug/L)	14	10	6	14	9	10 J	12	<10	<10	<5	<5	<10	<1	29 J	14	12	18 J	17	18 J	11	14 J	18
PCE	(ug/L)	50	36	19	38	32	38 J	50	<10	<10	<5	<5	<10	<1	25 J	22	19	34 J	64	40 J	39	48 J	74
trans 1,2 DCE	(ug/L)	NA		<2	NA	NA		3 J	NA	NA	NA	<5	NA	<2	NA	NA	NA		4 J	NA	NA		<2
cis 1,2 DCE	(ug/L)	NA		47	NA	NA		100	NA	NA	NA	2 J	NA	<2	NA	NA	NA		120	NA	NA		150
1,2 DCE (total)	(ug/L)	140	91	NA	140	89	88 J	NA	<10	<10	<5	NA	2 J	NA	130	57	51	76 J	NA	180	100	110 J	NA
Vinyl Chloride	(ug/L)	<10	<10	NA	<10	<10	<10	NA	<10	<10	<10	NA	<10	NA	<33	17	16	<25	NA	<50	<10	<10	NA
Acetone	(ug/L)	NA		<6	<10	NA		<6	10 J	10 J	NA	11 J	<10 J	<6	45 J	NA	NA		<6	<50	NA		<6
Methylene Chloride	(ug/L)	<5		<2	<10	<5		<2	<10	<10	<5	<5	<10	<2	<21	<5	<5		<2	<50	<5		<2
Total Petroleum Hydrocarbons																							
Gasoline Range	(mg/L)	<0.4	NA	NA	NA	<0.4	NA	NA	NA	NA	5.1	NA	NA	NA	NA	<0.4	<0.4	NA	NA	NA	<0.4	NA	NA
Kerosene Range	(mg/L)	<0.4	NA	NA	NA	<0.4	NA	NA	NA	NA	<0.4	NA	NA	NA	NA	<0.4	<0.4	NA	NA	NA	<0.4	NA	NA
Diesel/#2 Range	(mg/L)	<0.4	NA	NA	NA	<0.4	NA	NA	NA	NA	<0.4	NA	NA	NA	NA	<0.4	<0.4	NA	NA	NA	<0.4	NA	NA
Total Petroleum Hydrocarbons	(mg/L)	NA	NA	NA	<0.5	NA	NA	NA	1.7	NA	NA	NA	21 D	NA	<0.5	NA	NA	NA	NA	<0.5	NA	NA	NA
Polynuclear Aromatic Hydrocarbons																							
Naphthalene	(ug/L)	<10	<10	NA	<10	<10	<10	NA	<10	NA	<10	NA	<10	NA	<10	<10	<10	<10	NA	<10	<10	<10	NA
Fluorene	(ug/L)	<2	<10	NA	<10	<2	<10	NA	5 J	NA	5	NA	9 J	NA	<10	<2	<2	<10	NA	<10	<2	<10	NA
Phenathrene	(ug/L)	<2	<10	NA	<10	<2	<10	NA	<10	NA	<2	NA	2 J	NA	<10	<2	<2	<10	NA	<10	<2	<10	NA
Anthracene	(ug/L)	<1	<10	NA	<10	<1	<10	NA	<10	NA	<1	NA	<10	NA	<10	<1	<1	<10	NA	<10	<1	<10	NA
Pyrene	(ug/L)	<2	<10	NA	<10	<2	<10	NA	<10	NA	<2	NA	<10	NA	<10	<2	<2	<10	NA	<10	<2	<10	NA
Chrysene	(ug/L)	<1	<10	NA	<10	<1	<10	NA	<10	NA	<1	NA	<10	NA	<10	<1	<1	<10	NA	<10	<1	<10	NA
Benzo(a) pyrene	(ug/L)	<0.2	<10	NA	<10	<0.2	<10	NA	<10	NA	<0.2	NA	<10	NA	<10	<0.2	<0.2	<10	NA	<10	<0.2	<10	NA
Benzo (g,h,i) perylene	(ug/L)	<0.5	<10	NA	<10	<0.5	<10	NA	<10	NA	<0.5	NA	<10	NA	<10	<0.5	<0.5	<10	NA	<10	<0.5	<10	NA
Benzo (b) fluoranthrene	(ug/L)	<0.2	<10	NA	<10	<0.2	<10	NA	<10	NA	<0.2	NA	<10	NA	<10	<0.2	<0.2	<10	NA	<10	<0.2	<10	NA
General Water Chemistry																							
Total Suspended Solids	(mg/L)	NA	<10	NA	NA	NA	478	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	45	NA	NA	NA	<10	NA
Carbon Dioxide	(mg/L)	523	NA	76	NA	572	NA	102	NA	NA	640	104	NA	173	NA	511	551	NA	89	NA	516	NA	74
Dissolved Oxygen	(mg/L)	3.4	NA	NA	NA	5	NA	NA	NA	NA	<0.2	NA	NA	NA	NA	1.9	2.1	NA	NA	NA	2.5	NA	NA

Notes:
1. NA = Not Analyzed.
2. R = Rejected.
3. J = Estimated value.
4. * = Elevated chlorinated organic detection limit as a result of aromatic hydrocarbon detections.

Table 2-4
Summary of Ground-Water Elevation Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Well Location	Top of Casing Elevation (feet)	Date	Depth to Product (feet)	Depth to Water (feet)	Apparent Product Thickness (feet)	Corrected Ground-Water Elevation (feet)
CHT-2	161.86	4/5/94	NE	13.94	0.00	147.92
		5/23/94	NE	15.05	0.00	146.81
		9/28/96	NE	11.88	0.00	149.98
		10/5/96	NE	11.65	0.00	150.21
		10/6/96	NE	11.62	0.00	150.24
		10/11/96	NE	12.10	0.00	149.76
		10/14/96	NE	12.17	0.00	149.69
CHT-3	161.86	4/5/94	NE	16.64	0.00	145.22
		5/23/94	NE	17.58	0.00	144.28
		9/28/96	16.86	16.98	0.12	144.97
		10/2/96	15.79	16.02	0.23	146.01
		10/3/96	16.40	16.64	0.24	145.40
		10/4/96	15.98	16.03	0.05	145.87
		10/5/96	15.92	15.95	0.03	145.93
		10/6/96	16.02	16.07	0.05	145.83
		10/11/96	17.02	17.05	0.03	144.83
		10/14/96	17.22	17.27	0.05	144.63
CHT-7D	158.29	5/23/94	NE	16.29	0.00	142.00
		9/30/96	NE	15.79	0.00	142.50
		10/6/96	NE	15.62	0.00	142.67
		10/11/96	NE	16.11	0.00	142.18
		10/14/96	NE	16.40	0.00	141.89
DW-1	167.16	4/5/94	NE	13.12	0.00	154.04
		5/10/94	NE	13.68	0.00	153.48
		5/23/94	NE	13.63	0.00	153.53
	166.98	10/5/96	NE	12.45	0.00	154.53
		10/6/96	NE	12.50	0.00	154.48
		10/11/96	NE	15.96	0.00	151.02
		10/14/96	NE	16.03	0.00	150.95
MW-8	167.54	9/10/92	NE	17.96	0.00	149.58
		9/17/92	NM	NM	NM	NM
		9/28/92	NE	17.03	0.00	150.51
		10/28/92	NE	12.00	0.00	155.54
		11/9/92	NE	12.57	0.00	154.97
		11/16/92	NE	12.20	0.00	155.34
		4/5/94	NE	13.13	0.00	154.41
		5/10/94	NE	13.70	0.00	153.84
		5/23/94	NE	13.64	0.00	153.90
	167.30	9/28/96	NE	14.95	0.00	152.35
		10/5/96	NE	12.53	0.00	154.77
		10/6/96	NE	12.60	0.00	154.70
		10/11/96	NE	15.57	0.00	151.73
		10/14/96	NE	15.61	0.00	151.69
MW-9	162.26	9/10/92	NE	NM	NM	NM
		9/17/92	NE	12.56	Sheen	149.70
		9/28/92	NE	12.49	0.00	149.77
		10/28/92	NE	11.33	0.00	150.93
		11/9/92	NE	NM	NM	NM
		11/16/92	NE	10.95	0.00	151.31
		5/10/94	NE	11.76	0.00	150.50
		5/23/94	NE	11.75	0.00	150.51
	162.26	10/5/96	NE	14.30	0.00	147.96
		10/6/96	NE	14.46	0.00	147.80
		10/14/96	NE	14.96	0.00	147.30

Table 2-4
Summary of Ground-Water Elevation Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Well Location	Top of Casing Elevation (feet)	Date	Depth to Product (feet)	Depth to Water (feet)	Apparent Product Thickness (feet)	Corrected Ground-Water Elevation (feet)
MW-9S	162.37	9/17/92	NE	13.22	Sheen	149.15
		9/28/92	13.00	13.11	0.11	149.34
		10/28/92	NE	10.92	Sheen	151.45
		11/9/92	NE	10.94	0.00	151.43
		11/16/92	NE	10.47	Sheen	151.90
		5/10/94	NE	11.54	0.00	150.83
		5/23/94	NE	11.56	0.00	150.81
	162.37	9/28/96	NE	14.40	0.00	147.97
		10/6/96	NE	11.29	0.00	151.08
		10/11/96	NE	11.95	0.00	150.42
		10/14/96	NE	12.02	0.00	150.35
MW-10	161.5	9/10/92	NE	20.66	0.00	140.84
		9/17/92	NE	20.70	0.00	140.80
		9/28/92	NE	20.52	0.00	140.98
		10/28/92	NE	17.66	0.00	143.84
		11/9/92	NE	17.42	0.00	144.08
		11/16/92	NE	16.72	0.00	144.78
		4/5/94	NE	17.68	0.00	143.82
		5/10/94	NE	17.58	0.00	143.92
		5/23/94	NE	17.65	0.00	143.85
		9/28/96	NE	16.92	0.00	144.58
		10/5/96	NE	16.97	0.00	144.53
		10/6/96	NE	17.05	0.00	144.45
		10/11/96	NE	17.69	0.00	143.81
		10/14/96	NE	17.97	0.00	143.53
MW-10D	161.38	9/10/92	NE	20.96	0.00	140.42
		9/17/92	NE	21.06	0.00	140.32
		9/28/92	NE	20.98	0.00	140.40
		10/28/92	NE	17.84	0.00	143.54
		11/9/92	NE	17.88	0.00	143.50
		11/16/92	NE	17.26	0.00	144.12
		4/5/94	NE	17.70	0.00	143.68
		5/10/94	NE	17.76	0.00	143.62
		5/23/94	NE	18.09	0.00	143.29
		9/28/96	NE	17.60	0.00	143.78
		10/5/96	NE	17.42	0.00	143.96
		10/6/96	NE	17.53	0.00	143.85
		10/11/96	NE	18.20	0.00	143.18
		10/14/96	NE	18.50	0.00	142.88
SW-1	166.36	12/20/93	NE	18.40	0.00	147.96
		4/5/94	NE	20.07	0.00	146.29
		5/10/94	NE	9.10	0.00	157.26
		5/23/94	NE	20.50	0.00	145.86
	166.35	9/27/96	NE	19.15	0.00	147.20
		9/27/96	NE	19.15	0.00	147.20
		10/3/96	NE	19.51	0.00	146.84
		10/4/96	NE	20.28	0.00	146.07
		10/5/96	NE	19.42	0.00	146.93
		10/6/96	NE	19.39	0.00	146.96
		10/11/96	NE	20.19	0.00	146.16

Table 2-4
Summary of Ground-Water Elevation Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Well Location	Top of Casing Elevation (feet)	Date	Depth to Product (feet)	Depth to Water (feet)	Apparent Product Thickness (feet)	Corrected Ground-Water Elevation (feet)
SW-2	166.52	12/20/93	NE	16.10	0.00	150.42
		4/5/94	NE	17.53	0.00	148.99
		5/10/94	NE	18.45	0.00	148.07
		5/23/94	NE	17.43	0.00	149.09
	166.67	9/27/96	NE	17.00	0.00	149.67
		9/27/96	NE	17.00	0.00	149.67
		10/3/96	NE	17.65	0.00	149.02
		10/3/96	NE	17.72	0.00	148.95
		10/3/96	NE	17.72	0.00	148.95
		10/4/96	NE	17.40	0.00	149.27
		10/5/96	NE	17.21	0.00	149.46
		10/6/96	NE	17.25	0.00	149.42
		10/11/96	NE	18.45	0.00	148.22
		10/14/96	NE	18.65	0.00	148.02
SW-3	166.68	12/20/93	NE	15.79	0.00	150.89
		4/5/94	NE	17.16	0.00	149.52
		5/10/94	NE	18.96	0.00	147.72
		5/23/94	NE	17.62	0.00	149.06
	166.65	9/27/96	16.30	16.60	0.30	150.27
		10/1/96	16.70	16.99	0.29	149.87
		10/3/96	17.02	17.29	0.27	149.56
		10/3/96	17.02	17.29	0.27	149.56
		10/3/96	17.02	17.28	0.26	149.56
		10/4/96	17.36	17.59	0.23	149.23
		10/5/96	27.94	27.96	0.02	138.70
		10/6/96	23.61	23.66	0.05	143.03
		10/11/96	16.98	17.01	0.03	149.66
		10/12/96	17.14	17.18	0.04	149.50
		10/14/96	17.25	17.32	0.07	149.38
SW-7	167.02	12/20/93	9.41	9.40	0.01	157.63
		4/5/94	NE	9.72	0.00	157.30
		5/10/94	NE	10.08	0.00	156.94
		5/23/94	NE	10.77	0.00	156.25
	167.00	9/19/96	9.21	9.55	0.34	157.75
		10/3/96	9.45	9.67	0.22	157.52
		10/5/96	9.50	9.51	0.01	157.50
		10/6/96	9.55	9.60	0.05	157.44
		10/11/96	9.58	9.60	0.02	157.42
		10/12/96	9.61	9.64	0.03	157.39
		10/14/96	9.59	9.61	0.02	157.41
SW-8	167.47	9/23/96	NE	19.90	0.00	147.57
		9/24/96	NE	20.00	0.00	147.47
		9/25/96	NE	20.22	0.00	147.25
		9/26/96	NE	20.30	0.00	147.17
		10/3/96	NE	20.46	0.00	147.01
		10/5/96	NE	20.26	0.00	147.21
		10/6/96	NE	20.34	0.00	147.13
		10/11/96	NE	20.96	0.00	146.51
		10/14/96	NE	21.16	0.00	146.31

Notes:
1. NE = Not Encountered.
2. NM = Not Measured.
3. A specific gravity of 0.88 was used to calculate corrected ground-water elevation in monitoring well SW-7. In any other monitoring wells containing free product a value of 0.74 was used.

Table 2-5
Summary of Phase-Separated Hydrocarbon Analyses
Esso Tutu Service Station
St. Thomas, U.S.V.I.
(all units reported as ppm)

Analytical Parameter	SW-3		SW-7		CHT-3	
	FES	EPA	FES	EPA	FES	EPA
Gasoline Additives						
MTBE	360	NA	10	NA	84	NA
DIPE	<50	NA	<2	NA	<50	NA
ETBE	<50	NA	<2	NA	<50	NA
TAME	<50	NA	<2	NA	<50	NA
Volatile Organic Compounds (EPA Method 8260)						
Benzene	990	2,500	8	<150	470	2.4 J
Toluene	200	<1,600	<2	<150	360	0.330 J
Ethylbenzene	8,600	8,700	62	35 J	11,000 *	3.5 J
m, p Xylene	17,000*		10		11,000*	
o Xylene	6,400		31		4,000	
Total Xylenes	23,400	36,000	41	50 J	15,000	6.8 J
Isopropylbenzene	4,400		55		6,500	
n-Propylbenzene	14,000*		210		15,000*	
Propylbenzene		15,000 J		140 J		3.3 J
1,3,5 Trimethylbenzene	14,000*		84		16,000*	
Trimethylbenzene		110,000 J		200 J		22 J
Ethyl-Methyl-Benzene		69,000 J		150 J		16 J
Diethyl Benzene				140 J		
Ethyl Dimethyl Benzene		25,000 J		560 J		2.8 J
Tetramethyl Benzene				260 J		
Ethenyl Dimethyl Benzene				210 J		
Dihydromethyl-1W-Indene				410 J		
Dihydrodimethyl-1W-Indene				190 J		
Ethyltrimethyl Benzene				160 J		
Hydrocarbons		28,000 J				
Dimethyl Heptane		9,400 J				
Methyl Heptane		13,000 J				
Trimethyl Heptane		15,000 J				
Methylpropylbenzene		14,000 J				1.5 J
Methoxy Methyl Propane						3 J
Methyl (Methyl Ethyl) Benzene						2.5 J
Indane						2.2 J
Unknown Compound #1						1.2 J
4-Chlorotoluene	860		13		<50	
1,2,4 Trimethylbenzene	19,000		120		20,000*	
sec-Butylbenzene	<50		35		3,100	
1,2 Dichlorobenzene	<50		15		<50	
1,4 Dichlorobenzene	<50		2		<50	
Trichloroethene	<50	<1,600	<2	<150	<50	
Tetrachloroethene	<50	<1,600	<2	<150	<50	
1,1, Dichloroethene	<50	<1,600	<2	<150	<50	
cis 1,2 Dichloroethene	<50		<2		<50	
trans 1,2 Dichloroethene	<50	<1,600	<2	<150	<50	
Naphthalene	5,300		300		4,100	0.890 J
Alcohols						
Methanol	<25	NA	<25	NA	<25	NA
2-Methyl-2-propanol	<25	NA	<25	NA	<25	NA
Ethanol	55	NA	<25	NA	31	NA
2-Butanol	<25	NA	<25	NA	<25	NA
1-Propanol	<25	NA	<25	NA	<25	NA
2-Methyl-1-propoanol	<25	NA	<25	NA	<25	NA
Neopentyl alcohol	<25	NA	<25	NA	<25	NA
1-Butanol	<25	NA	<25	NA	<25	NA
Lead Alkyls						
Tetramethyl Lead	<5	NA	<5	NA	<5	NA
Trimethylethyl Lead	<5	NA	<5	NA	<5	NA
Dimethyl-diethyl Lead	<5	NA	<5	NA	<5	NA
Triethyl-methyl Lead	<5	NA	<5	NA	<5	NA
Tetraethyl Lead	<5	NA	<5	NA	<5	NA

Notes:
1. MTBE = Methyl t-butyl ether.
2. DIPE = Diisopropyl ether.
3. ETBE = Ethyl t-butyl ether.
4. TAME = t-Amyl methyl ether.
5. * = "The value reported exceeded the highest calibration standard."

Table 3-1
Well Information
Remedial System Wells
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Well Designation	Top of Casing Elevation (ft)	Borehole Diameter	Well Diameter	Well Construction	Depth to Bedrock (ft)	Depth to Water (ft)	Screened Interval (ft)	Total Depth (ft)
Shallow Ground-Water Extraction/Biovent Injection Wells								
G1/BI	NA	7	4	PVC	NE	NA	5-15	15
G2/BI	NA	7	4	PVC	NE	NA	5-15	15
G3/B1	NA	7	4	PVC	NE	NA	5-15	15
G4/BI	NA	10	4	PVC	NE	NA	5-15	15
Deep Ground-Water Extraction Wells								
G5	NA	10	6	SS	27	NA	12-57.5	57.5
G6	NA	10	6	SS	1	NA	14-59	59
G7	NA	10	6	SS	24	NA	15-60	60
G8	NA	10	6	SS	3	NA	12.5-57.5	57.5
Biovent Injection Well								
BI	NA	7	2	PVC	NE	NA	5-15	15
Biovent Extraction Wells								
BE1	NA	10	2	PVC	NE	NA	5-15	15
BE2	NA	7	2	PVC	NE	NA	5-15	15
BE3	NA	7	2	PVC	NE	NA	5-15	15
BE4	NA	7	2	PVC	NE	NA	5-15	15
BE5	NA	7	2	PVC	NE	NA	5-15	15
Shallow Vapor Extraction Wells								
V1	NA	7	2	PVC	NE	NA	5-15	15
V2	NA	7	2	PVC	NE	NA	5-15	15
V3	NA	7	2	PVC	NE	NA	5-15	15
Deep Vapor Extraction Wells								
V4	NA	7	2	PVC	27	NA	15-30	30
V5	NA	7	2	PVC	20	NA	15-30	30

Table 3-1
Well Information
Monitoring Wells
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Well Designation	Top of Casing Elevation (ft)	Borehole Diameter	Well Diameter	Well Construction	Depth to Bedrock (ft)	Depth to Water (ft)	Screened Interval (ft)	Total Depth (ft)
Shallow Monitoring Wells								
SW-1	166.35	8	4	PVC	11	20.19	5-35	35
SW-2	166.67	8	4	PVC	8	18.65	5-35	35
SW-3	166.65	8	4	PVC	10	17.32	5-40	40
SW-4	152.96	8	4	PVC	12	NA	5-35	35
SW-5	142.21	8	4	PVC	9	NA	6-31	31
SW-6	147.60	8	4	PVC	9	NA	5-35	35
SW-7	167.00	8	4	PVC	NE	9.61	7-22	22
SW-8	167.47	8	4	PVC	20	21.16	4-39	39
SW-9	NA	10	4	PVC	6	NA	10-40	40
SW-10	NA	10	4	PVC	9	NA	10-40	40
MW-8	167.54	10	4	SS	8.3	15.61	5.5-25	25.5
MW-9	162.26	10	4	SS	5	14.96	14.1-34	34.1
MW-9S	162.37	6	4	SS	5	12.02	8.7-18	18.7
MW-10	161.50	10	4	SS	2.9	17.97	15.6-35	35.6
CHT-2	161.86	8	2	PVC	29	12.17	31-36	36
CHT-3	161.86	8	2	PVC	32	17.27	23-33	33

Table 3-1
Well Information
Monitoring Wells
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Well Designation	Top of Casing Elevation (ft)	Borehole Diameter	Well Diameter	Well Construction	Depth to Bedrock (ft)	Depth to Water (ft)	Screened Interval (ft)	Total Depth (ft)
Deep Monitoring Wells								
DW-1	167.16	5.25*	6	SS	8	16.03	65-80*	80
MW-10D	161.38	6	6	SS	1.7	18.5	55-75	75
CHT-7D	158.29	8	6	PVC	20	16.4	20-124	124
Vapor Monitoring Wells								
VW-1	NA	8	2	PVC	NE	NA	4.5-9.5	9.5
VW-2	NA	8	2	PVC	NE	NA	4.5-9.5	9.5
VW-3	NA	8	2	PVC	NE	NA	4.5-9.5	9.5
VW-4	NA	8	2	PVC	NE	NA	4-9	9
VW-5	NA	8	2	PVC	NE	NA	4-9	9
VW-6	NA	8	2	PVC	NE	NA	3.5-8.5	8.5
VW-7	NA	8	2	PVC	NE	NA	4-9	9
VW-8	NA	8	2	PVC	NE	NA	5-35	7.5
VW-9	NA	7	2	PVC	NE	NA	5-15	15
VW-10	NA	7	2	PVC	NE	NA	4.5-14.5	14.5
VW-11	NA	7	2	PVC	NE	NA	5-15	15

SS = stainless steel, PVC = polyvinyl chloride pipe
NA = Top of casing elevation and depths to bedrock/water measurements not available at time of tabulation.
Borehole and well diameters given in inches.
NE = Not Encountered
Depth to water measurements obtained on October 14, 1996.
* = Open borehole below 60 feet.

Table 4-1
SVE Pilot Test
Distance-Drawdown Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Extraction Well SW-3

Location	Distance from SW-3 (ft)	Vacuum at 30 minutes	Vacuum at 60 minutes	Vacuum at 90 minutes
SW-3	0	20"	40"	58" @ 15-18scfm
VW-7	5	0.22	0.70	1.20
VW-6	10	0.12	0.35	0.64
VW-8	16	0.23	0.54	0.95
VW-5	21	0.22	0.61	0.90
SW-2	34	0.15	0.34	0.65
SW-1	43	0.06	0.14	0.26
VW-4	63	0.01	0.08	0.15

Extraction Well VW-3

Location	Distance from VW-3 (ft)	Vacuum at 30 minutes	Vacuum at 60 minutes	Vacuum at 90 minutes
VW-3	0	20"	40"	53" @ 18-20scfm
SW-7	5	0.28	0.50	0.66
VW-4	15.5	0.04	0.07	0.10
VW-2	16	0.04	0.06	0.07
VW-1	17	0.04	0.06	0.07
SW-8	37	0.05	0.02*	0.01*
VW-5	45	0.01	0.01	0.01

* loss of vacuum due to short-circuiting/defective well seal
vacuum reported in inches of water column
scfm = air flow in standard cubic feet per minute, based on field measurements

Table 4-2
SVE System
Vapor Monitoring Points
Esso Tutu Service Station
St. Thomas, U.S.V.I.

V1	
VMPs	Distance from Wellhead (ft)
BI	10
BE-1	15
VW-11	25
BE-2	30
VW-1	40

V2	
VMPs	Distance from Wellhead (ft)
VW-1	10
SW-7	20
VW-2	30
VW-3	30
VW-11	60

V3	
VMPs	Distance from Wellhead (ft)
VW-6	5
VW-7	10
VW-5	25
VW-4	45
VW-9	60

V4	
VMPs	Distance from Wellhead (ft)
VW-7	5
VW-6	15
VW-8/9	20
VW-5	30
SW-2	45

V5	
VMPs	Distance from Wellhead (ft)
CHT-3	10
SW-1	15
VW-9	40
SW-2	55
VW-5	60

BE1	
VMPs	Distance from Wellhead (ft)
BI	15
V2	30
VW-11	40
VW-1	40
VW-3	50

BE2	
VMPs	Distance from Wellhead (ft)
VW-1	15
VW-3	20
VW-2	30
VW-4	40
VW-10/11	55

BE3	
VMPs	Distance from Wellhead (ft)
VW-10	15
VW-2	20
VW-1	25
VW-3	35
VW-4	45

BE4	
VMPs	Distance from Wellhead (ft)
VW-2	15
VW-4	25
VW-3	30
VW-10	25
VW-9	45

BE5	
VMPs	Distance from Wellhead (ft)
VW-4	20
VW-2	25
VW-9	25
VW-3	30
VW-5	45

V = vapor extraction well; BE = bioventing extraction well
VMPs = vapor monitoring points

Table 4-3a
Mass Removal and Air Emissions Calculations (Average System Discharge)
SVE/Bioventing System
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Compound	Average Soil Vapor Concentration		Molecular Weight	Average Contaminant Mass Per Well				Contaminant Mass All Wells @ 125 cfm		Contaminant Mass All Wells @ 175 cfm	
	ppbv	ppmv	gm/mole	mg/m^3	kg/m^3	kg/ft^3	lbs/ft^3	lbs/cfm	$lbs/ft^3/hour$	lbs/cfm	$lbs/ft^3/hour$
Pentane	135000	135.000	72.2	398.650	3.99E-04	1.13E-05	2.49E-05	0.0031	0.187	0.0044	0.261
Hexane	13350	13.350	86.2	47.066	4.71E-05	1.33E-06	2.94E-06	0.0004	0.022	0.0005	0.031
Heptane	200	0.200	100.2	0.820	8.20E-07	2.32E-08	5.12E-08	6.40E-06	3.84E-04	8.96E-06	5.37E-04
Isooctane	6550	6.550	114.2	30.593	3.06E-05	8.66E-07	1.91E-06	0.0002	0.014	0.0003	0.020
Octane	651	0.651	114.2	3.038	3.04E-06	8.60E-08	1.90E-07	2.37E-05	0.001	3.32E-05	0.002
Benzene	2880	2.880	78.1	9.200	9.20E-06	2.61E-07	5.74E-07	7.18E-05	0.004	1.01E-04	0.006
MTBE	11	0.011	88.2	0.038	3.79E-08	1.07E-09	2.36E-09	2.95E-07	1.77E-05	4.14E-07	2.48E-05
Toluene	466	0.466	92.1	1.753	1.75E-06	4.97E-08	1.09E-07	1.37E-05	0.001	1.92E-05	0.001
Ethylbenzene	6022	6.022	106.2	26.157	2.62E-05	7.41E-07	1.63E-06	0.0002	0.012	0.0003	0.017
m- & p- Xylenes	553	0.553	106.2	2.402	2.40E-06	6.80E-08	1.50E-07	1.87E-05	0.001	2.62E-05	0.002
o-Xylenes	154	0.154	106.2	0.669	6.69E-07	1.89E-08	4.18E-08	5.22E-06	3.13E-04	7.31E-06	4.39E-04
4-Ethyltoluene	382	0.382	120.2	1.876	1.88E-06	5.31E-08	1.17E-07	1.46E-05	0.001	2.05E-05	0.001
Cumene	2171	2.171	120.2	10.671	1.07E-05	3.02E-07	6.66E-07	0.0001	0.005	1.17E-04	0.007
1,2,4 Trimethylbenzene	604	0.604	120.2	2.967	2.97E-06	8.40E-08	1.85E-07	2.32E-05	1.39E-03	3.24E-05	1.95E-03
1,3,5 Trimethylbenzene	211	0.211	120.2	1.037	1.04E-06	2.94E-08	6.48E-08	8.10E-06	4.86E-04	1.13E-05	6.80E-04
Carbon Disulfide	26	0.026	76.1	0.081	8.09E-08	2.29E-09	5.05E-09	6.32E-07	3.79E-05	8.84E-07	5.31E-05
Freon 113	28	0.028	187.4	0.215	2.15E-07	6.08E-09	1.34E-08	1.67E-06	1.00E-04	2.34E-06	1.41E-04
Trichloroethene	29	0.029	131.4	0.156	1.56E-07	4.41E-09	9.73E-09	1.22E-06	7.30E-05	1.70E-06	1.02E-04
Tetrachloroethane	230	0.230	165.8	1.560	1.56E-06	4.42E-08	9.74E-08	1.22E-05	7.30E-04	1.70E-05	1.02E-03
TICs/C_3-C_4	16945	16.945	86.2	59.741	5.97E-05	1.69E-06	3.73E-06	0.0005	0.028	0.0007	0.039
TICs/C_5-C_{10}	14275	14.275	184.4	107.661	1.08E-04	3.05E-06	6.72E-06	8.40E-04	0.050	0.0012	0.071
	A	B = A/1000	C	D = BxC/24.45	E = D/1000000	F = E/35.31	G = Fx2.20	H = Gx125	I = Hx60	H = Gx125	I = Hx60

Total vapor contaminant mass removed by treatment system in pounds/hour =	**0.331**		**0.463**
Total estimated air emission in pounds/hour (assumes minimum cat-ox destruction efficiency of 95%) =	**0.017**		**0.023**

ppbv = parts per billion by volume, ppmv = parts per million by volume, mg = milligrams, gm = grams, kg = kilograms, lbs = pounds,
m^3 = cubic meters, ft^3 = cubic feet, cfm = cubic feet per minute, 24.45 = avg. molecular wt. of air
TICs = tentatively identified compounds. For estimation purposes, the TIC with the highest molecular weight in
each group (2,2-dimethylbutane, 2,3,4,-trimethyldecane) was used in the calculations.
Average soil vapor concentrations based on quantitative vapor samples collected from SW-3 and VW-3 in October 1996.
Total estimated air flow from all extraction wells is estimated at 125 cfm. Catalytic oxidizer will provide at least 95% treatment efficiency.

Table 4-3b
Mass Removal and Air Emissions Calculations (Maximum System Discharge)
SVE/Bioventing System
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Compound	Maximum Soil Vapor Concentration		Molecular Weight	Average Contaminant Mass Per Well				Contaminant Mass All Wells @ 125 cfm		Contaminant Mass All Wells @ 175 cfm	
	ppbv	ppmv	gm/mole	mg/m^3	kg/m^3	kg/ft^3	lbs/ft^3	lbs/cfm	lbs/ft^3/hour	lbs/cfm	lbs/ft^3/hour
Pentane	260000	260.000	72.2	767.771	7.68E-04	2.17E-05	4.79E-05	0.0060	0.360	0.0084	0.503
Hexane	19000	19.000	86.2	66.986	6.70E-05	1.90E-06	4.18E-06	0.0005	0.031	0.0007	0.044
Heptane	200	0.200	100.2	0.820	8.20E-07	2.32E-08	5.12E-08	6.40E-06	3.84E-04	8.96E-06	5.37E-04
Isooctane	9200	9.200	114.2	42.971	4.30E-05	1.22E-06	2.68E-06	0.0003	0.020	0.0005	0.028
Octane	1300	1.300	114.2	6.072	6.07E-06	1.72E-07	3.79E-07	4.74E-05	0.003	0.0001	0.004
Benzene	5500	5.500	78.1	17.569	1.76E-05	4.98E-07	1.10E-06	0.0001	0.008	0.0002	0.012
MTBE	20	0.020	88.2	0.072	7.21E-08	2.04E-09	4.50E-09	5.63E-07	3.38E-05	7.88E-07	4.73E-05
Toluene	920	0.920	92.1	3.466	3.47E-06	9.81E-08	2.16E-07	2.70E-05	0.002	3.79E-05	0.002
Ethylbenzene	12000	12.000	106.2	52.123	5.21E-05	1.48E-06	3.25E-06	0.0004	0.024	0.0006	0.034
m- & p- Xylenes	1100	1.100	106.2	4.778	4.78E-06	1.35E-07	2.98E-07	3.73E-05	0.002	0.0001	0.003
o-Xylenes	300	0.300	106.2	1.303	1.30E-06	3.69E-08	8.14E-08	1.02E-05	6.10E-04	1.42E-05	8.54E-04
4-Ethyltoluene	760	0.760	120.2	3.736	3.74E-06	1.06E-07	2.33E-07	2.92E-05	0.002	4.08E-05	0.002
Cumene	4300	4.300	120.2	21.139	2.11E-05	5.99E-07	1.32E-06	0.0002	0.010	0.0002	0.014
1,2,4 Trimethylbenzene	1200	1.200	120.2	5.899	5.90E-06	1.67E-07	3.68E-07	4.60E-05	0.003	0.0001	0.004
1,3,5 Trimethylbenzene	420	0.420	120.2	2.065	2.06E-06	5.85E-08	1.29E-07	1.61E-05	9.67E-04	2.26E-05	0.001
Carbon Disulfide	50	0.050	76.1	0.156	1.56E-07	4.41E-09	9.72E-09	1.21E-06	7.29E-05	1.70E-06	1.02E-04
Freon 113	50	0.050	187.4	0.383	3.83E-07	1.09E-08	2.39E-08	2.99E-06	1.79E-04	4.19E-06	2.51E-04
Trichloroethene	29	0.029	131.4	0.156	1.56E-07	4.41E-09	9.73E-09	1.22E-06	7.30E-05	1.70E-06	1.02E-04
Tetrachloroethane	230	0.230	165.8	1.560	1.56E-06	4.42E-08	9.74E-08	1.22E-05	7.30E-04	1.70E-05	0.001
TICs/C_3-C_4	31500	31.500	86.2	111.055	1.11E-04	3.15E-06	6.93E-06	0.0009	0.052	0.0012	0.073
TICs/C_5-C_{10}	26000	26.000	184.4	196.090	1.96E-04	5.55E-06	1.22E-05	0.0015	0.092	2.14E-03	0.129
	A	B = A/1000	C	D = BxC/24.45	E = D/1000000	F = E/35.31	G = Fx2.20	H = Gx125	I = Hx60	H = Gx125	I = Hx60

Total vapor contaminant mass removed by treatment system in pounds/hour =	**0.612**		**0.856**
Total estimated air emission in pounds/hour (assumes minimum cat-ox destruction efficiency of 95%) =	**0.031**		**0.043**

ppbv = parts per billion by volume, ppmv = parts per million by volume, mg = milligrams, gm = grams, kg = kilograms, lbs = pounds,
m^3 = cubic meters, ft^3 = cubic feet, cfm = cubic feet per minute, 24.45 = avg. molecular wt. of air
TICs = tentatively identified compounds. For estimation purposes, the TIC with the highest molecular weight in each group (2,2-dimethylbutane, 2,3,4,-trimethyldecane) was used in the calculations.
Maximum soil vapor concentrations based on quantitative vapor samples collected from SW-3 in October 1996.
Total estimated air flow from all extraction wells is estimated at 125 cfm. Catalytic oxidizer will provide at least 95% treatment efficiency.

Table 4-4
Summary of Aquifer Testing Results
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Location	Monitoring Point	Aquifer Thickness	Theis	Cooper-Jacob	Theis Recovery	Moench
CHT-2	Pumping Well	30 feet	K = 0.00008 ft/min S = 0.27	K = 0.000054 ft/min S = 0.44	K = 0.000021 ft/min NA	K = 0.000004 ft/min NA
MW-9	Observation Well	30 feet	K = 0.0013 ft/min S = 0.018	K = 0.002 ft/min S = 0.012	NA NA	K = 0.0012 ft/min NA
MW-9s	Observation Well	30 feet	K = 0.0004 ft/min S = 0.03	K = 0.0006 ft/min S = 0.02	NA NA	NA NA
SW-1	Pumping Well	30 feet	K = 0.000043 ft/min S = 0.21	K = 0.000064 ft/min S = 0.16	K = 0.00016 ft/min NA	K = 0.0008 ft/min NA
SW-3	Pumping Well	40 feet	K = 0.000019 ft/min S = 0.17	K = 0.000025 ft/min S = 0.15	K = 0.000077 ft/min NA	K = 0.0001 ft/min NA
SW-7	Pumping Well	12 feet	K = 0.0006 ft/min S = 0.21	K = 0.00059 ft/min S = 0.21	K = 0.000092 ft/min NA	NA NA

Notes:
1. NA = Not Analyzed.

Table 4-5
Ground-Water Extraction System
Monitoring Points
Esso Tutu Service Station
St. Thomas, U.S.V.I.

G1	
MPs	Distance from Wellhead (ft)
VW-1	15
VW-2	35
VW-3	35
G1	Dewater Well Total Depth = 15 ft.

G2	
MPs	Distance from Wellhead (ft)
VW-1	5
VW-2	15
VW-3	10
G2	Dewater Well Total Depth = 15 ft.

G3	
MPs	Distance from Wellhead (ft)
VW-3	5
VW-4	10
VW-2	25
G3	Dewater Well Total Depth = 15 ft.

G4	
MPs	Distance from Wellhead (ft)
VW-4	10
VW-5	20
VW-6	20
G4	Dewater Well Total Depth = 15 ft.

G5	
MPs	Distance from Wellhead (ft)
SW-3	5
VW-5*	10
SW-2	30

G6	
MPs	Distance from Wellhead (ft)
MW-9	5
MW-9S	25
CHT-2	30

G7	
MPs	Distance from Wellhead (ft)
SW-8	5
VW-2	30
VW-9/10	35

G8	
MPs	Distance from Wellhead (ft)
MW-10	5
SW-9	30
CHT-3	35

G = Ground-water extraction well, G1-G4 are "shallow" perched water wells, G5-G8 are "deep" localized Tutu aquifer wells
MPs = monitoring points
* = VW will dewater as perched zone is dewatered

Table 4-6
Ground-Water Contaminant Calculations
Ground-Water Extraction System (Air Stripper Design and Contaminant Mass Removal)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Ground-Water Extraction Well (representative wells)	Water Source/ Expected Yield	% System Total Flow
G1 (SW-7)	perched water table/ 0.5 gpm	8.3%
G2 (SW-7)	perched water table/ 0.5 gpm	8.3%
G3 (SW-7)	perched water table/ 0.5 gpm	8.3%
G4 (SW-7)	perched water table/ 0.5 gpm	8.3%
G5 (SW-3)	shallow Tutu Aquifer/ 1.0 gpm	16.7%
G6 (MW-9, MW-9S, CHT-2)	shallow Tutu Aquifer/ 1.0 gpm	16.7%
G7 (SW-8)	shallow Tutu Aquifer/ 1.0 gpm	16.7%
G8 (MW-10, MW-10D, SW-1, CHT-3)	shallow Tutu Aquifer/ 1.0 gpm	16.7%

gpm = gallons per minute
All 1996 data from representative wells averaged to calculate weighted flow concentrations except G8; MW-10 & MW-10D averaged for CVOCs, SW-1 & CHT-2 averaged for VOCs to provide "worst-case" scenarios. See Table 2-1 for 1996 analytical data.

Compound	Weighted Flow Concentration mg/L	Design Concentration mg/L
Benzene	2222	2,250
Toluene	134	150
Ethylbenzene	684	700
Xylenes	1856	1,900
Total BTX	4211	4,300
MTBE	19939	20,000
Tetrachloroethene	12	5
Trichloroethene	3	15
1,2 Dichloroethene (total)	24	25
Vinyl Chloride	3	5
Acetone	2	5
Methylene Chloride	14	15

μg/L = micrograms per liter

Table 4-7
Contaminant Mass Removal
Ground-Water Extraction System
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Compound	Weighted Flow Concentration			Contaminant Mass @ 10 gpm			Total Contaminant Mass in lbs/hr		
	µg/L	mg/L	gm/L	gm/gal	gm/min	gm/hr	6 gpm	10 gpm	12gpm
Benzene	2222	2.222	0.0022	0.0084	0.0841	5.0456	0.0070	0.0116	0.0139
Toluene	134	0.134	0.0001	0.0005	0.0051	0.3036	0.0004	0.0007	0.0008
Ethylbenzene	684	0.684	0.0007	0.0026	0.0259	1.5541	0.0021	0.0036	0.0043
Xylenes	1856	1.856	0.0019	0.0070	0.0702	4.2144	0.0058	0.0097	0.0116
MTBE	19939	19.939	0.0199	0.0755	0.7547	45.2813	0.0624	0.1040	0.1248
Tetrachloroethene	12	0.012	1.20E-05	4.54E-05	0.0005	0.0273	3.75E-05	0.0001	0.0001
Trichloroethene	3	0.003	3.00E-06	1.14E-05	0.0001	0.0068	9.39E-06	1.56E-05	1.88E-05
1,2 Dichloroethene (total)	23	0.023	2.30E-05	0.0001	0.0009	0.0522	0.0001	0.0001	0.0001
Vinyl Chloride	3	0.003	3.00E-06	1.14E-05	0.0001	0.0068	9.39E-06	1.56E-05	1.88E-05
Acetone	2	0.002	2.00E-06	7.57E-06	0.0001	0.0045	6.26E-06	1.04E-05	1.25E-05
Methylene Chloride	14	0.014	1.40E-05	0.0001	0.0005	0.0318	4.38E-05	0.0001	0.0001
	A	B = A/1000	C = B/1000	D = Cx3.785	E = Dx10	F = Ex60	G = H*0.6	H = F/435.5	I = H*1.2
Total estimated mass removal in pounds/hour =							**0.0779**	**0.1298**	**0.1558**

L = liters, µg = microgram, mg = milligrams, gm = grams, gal = gallons, gpm = gallons per minute, min = minutes, lbs = pounds, hr = hour
Weighted contaminant concentrations based on quantitative ground-water samples collected at the site in September/October 1996. Table 2-3 provides analytical data. Table 4-6 provides assumptions used to calculate weighted flow concentrations.
For air emission calculations, assume air stripper will operate with 100% treatment efficiency.

Table 10-1
Construction Organization Chart
Tutu Source Control Program
Esso Tutu Service Station
St. Thomas, U.S.V.I.

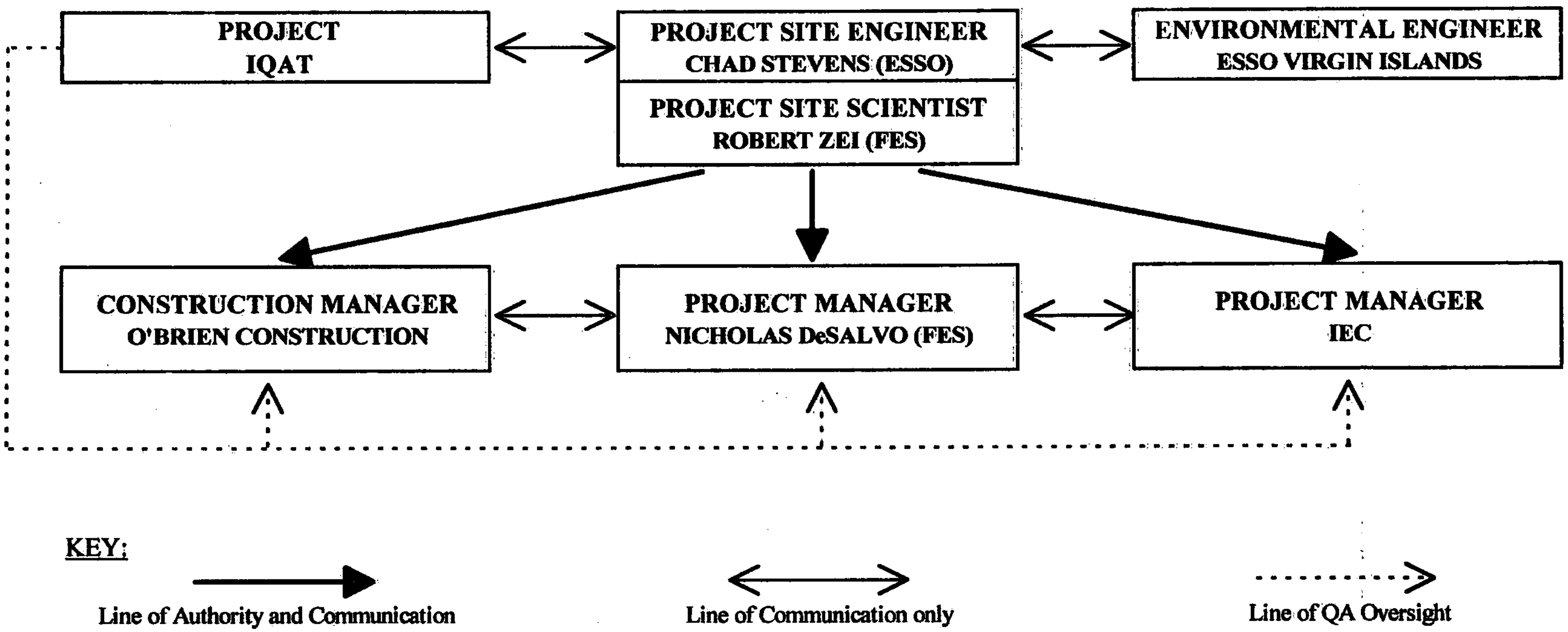


Table 10-2
Construction Implementation Schedule
Tutu Source Control Program
Esso Tutu Service Station
St. Thomas, U.S.V.I.

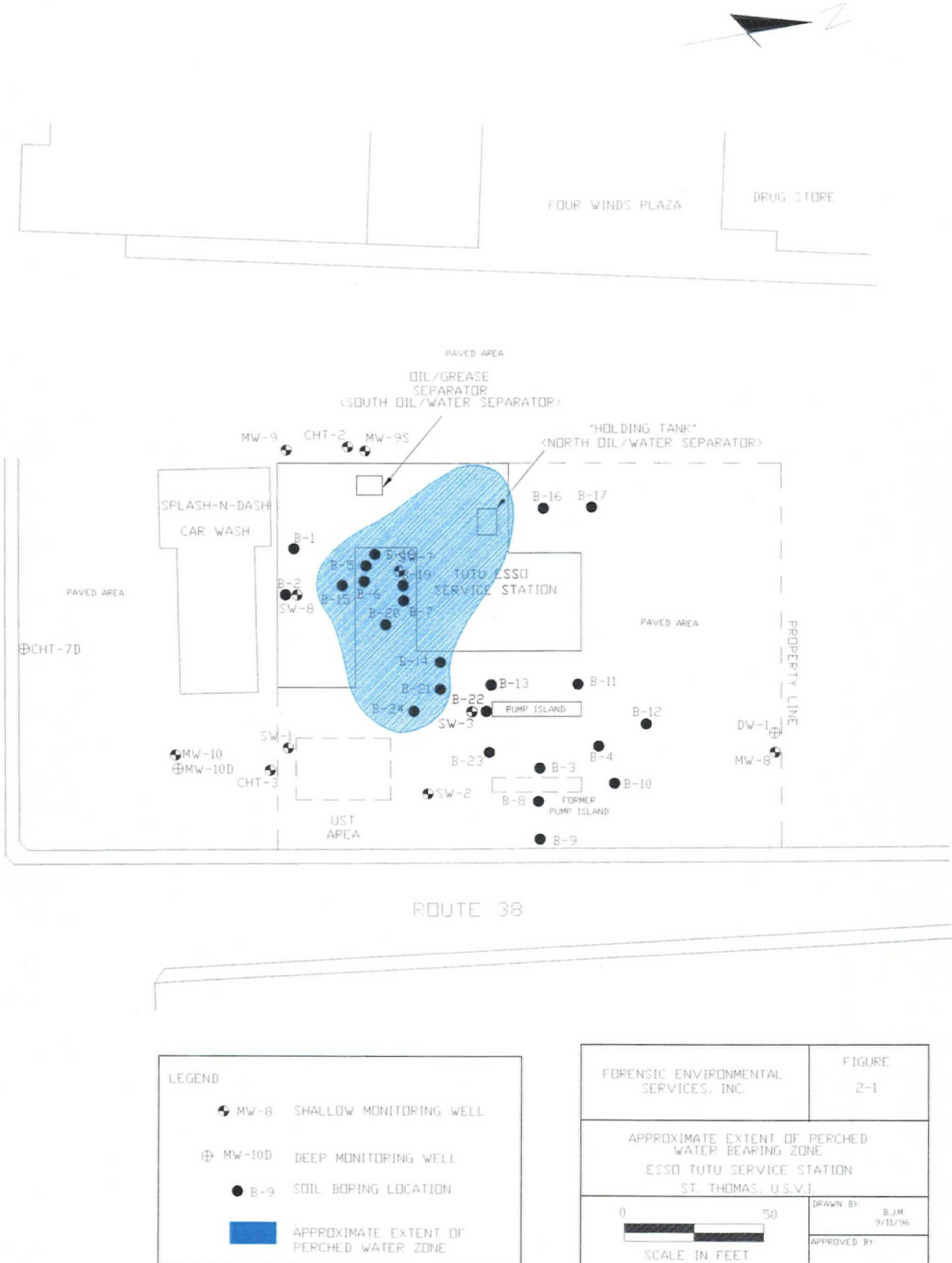
	Pre-Sept.	September 1998				October 1998				November 1998				December 1998				January 1999				February 1999				March 1999			
	1998	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Obtain Permits																													
2. Demolition of Station Buildings																													
3. Power Drop at Site																													
4. Install G-W/Vapor Recovery Wells																													
5. Trenching/Pipe Installation																													
6. Install Treatment Container Pad																													
7. Order Treatment System Equipment																													
8. Assemble Treatment System Components																													
9. Pre-Shipment Testing of Treatment System																													
10. Shipment of Treatment System Trailer																													
11. Treatment Trailer Installation/Connection																													
12. Submit Final RD Report																													
13. Submit O&M Plan																													
14. Submit RAWP																													
15. Submit ITP																													
16. EPA Review of ITP																													
17. System Activation - ITP Implementation																													

Final system start-up will follow EPA approval of ITP activities.

Table 10-3
Construction Cost Estimate
Tutu Source Control Program
Esso Tutu Service Station
St. Thomas, U.S.V.I.

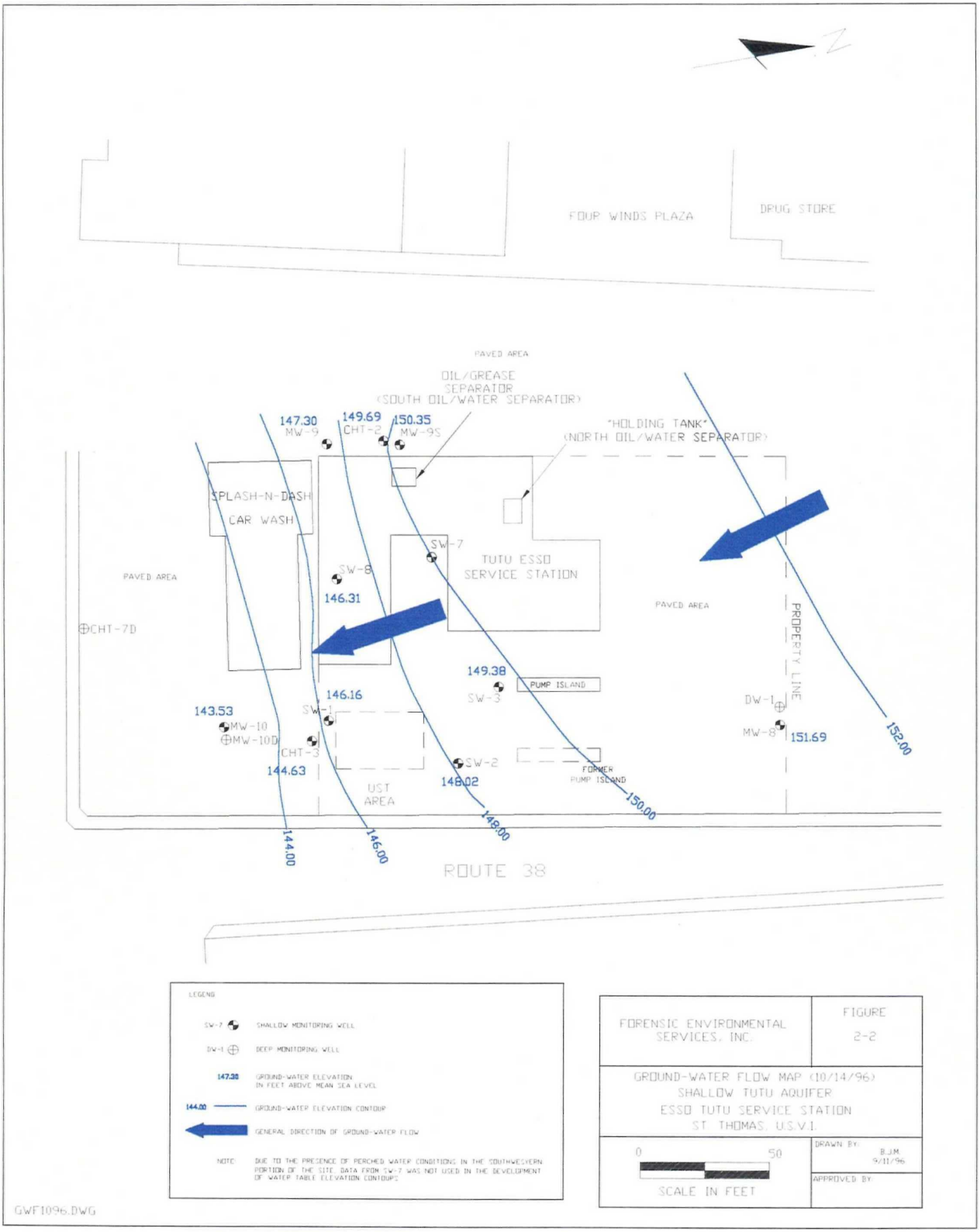
	Estimated Cost
1. Final Remedial Design	$40,000
2. Utility Connections, Permitting	$15,000
3. Installation of G-W/Vapor Recovery Wells	$240,000
4. Installation of Trenching/Piping	$161,000
5. Remedial Treatment System Assembly	$175,000
6. Remedial Treatment System Shipment & Installation	$45,000
7. System Activation - ITP Implementation, 4 months O&M	$60,000
8. UAO/Compliance Reporting	$115,000
9. Soil Disposal (Well/Trench Installation)	$100,000
TOTAL	$951,000

FIGURES

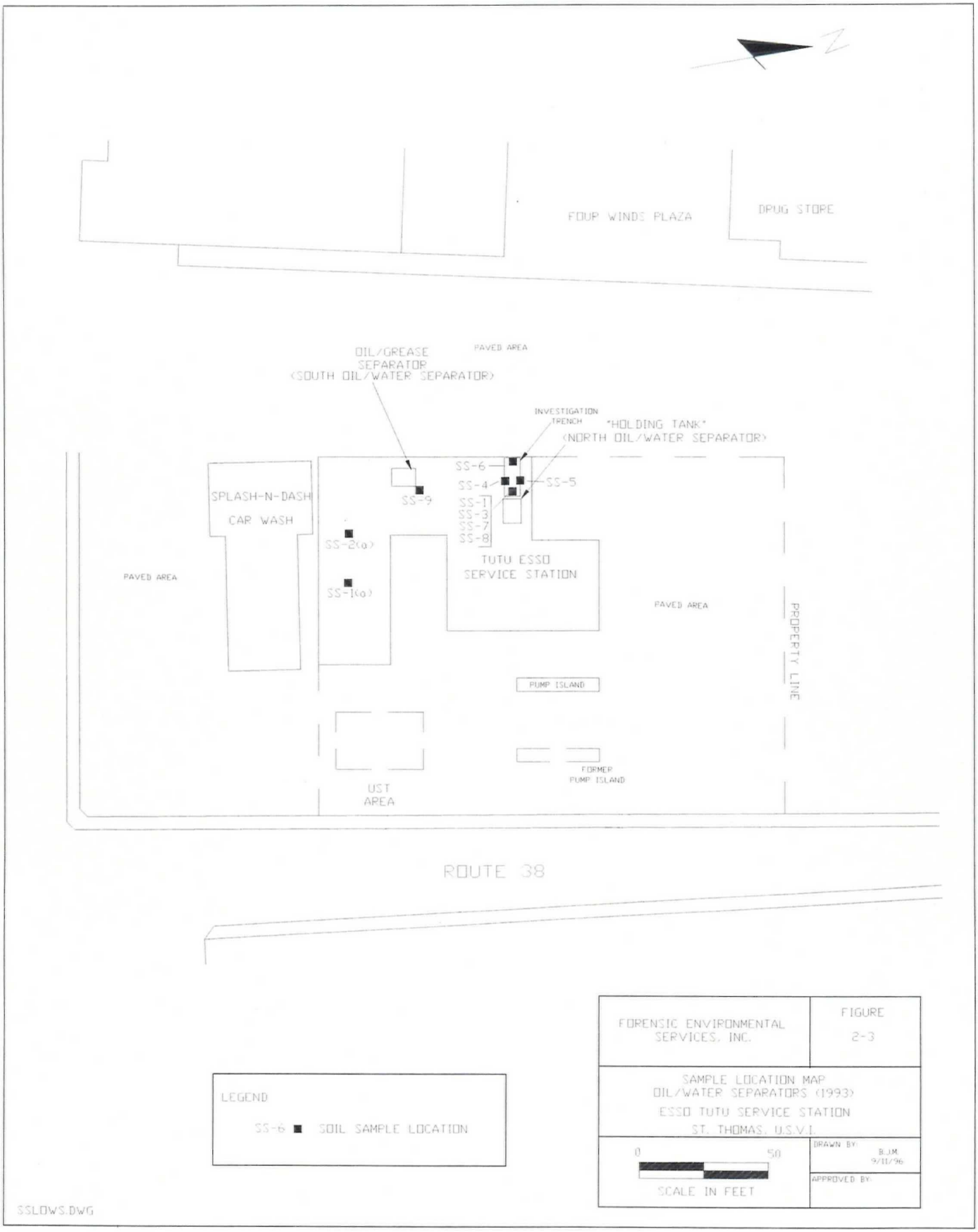


FORENSIC ENVIRONMENTAL SERVICES, INC.	FIGURE 2-1
APPROXIMATE EXTENT OF PERCHED WATER BEARING ZONE ESSO TUTU SERVICE STATION ST. THOMAS, U.S.V.I.	
0 50 SCALE IN FEET	DRAWN BY: B.J.M. 9/11/96 APPROVED BY:

PERCHED.DWG



FOUR WINDS PLAZA
DRUG STORE
PAVED AREA
OIL/GREASE SEPARATOR (SOUTH OIL/WATER SEPARATOR)
"HOLDING TANK" (NORTH OIL/WATER SEPARATOR)
147.30
MW-9
149.69
CHT-2
150.35
MW-9S
SPLASH-N-DASH CAR WASH
SW-7
TUTU ESSO SERVICE STATION
SW-8
146.31
PAVED AREA
PAVED AREA
PROPERTY LINE
CHT-7D
149.38
SW-3
PUMP ISLAND
146.16
SW-1
143.53
MW-10
MW-10D
CHT-3
144.63
UST AREA
SW-2
148.02
FORMER PUMP ISLAND
DW-1
MW-8
151.69
152.00
150.00
148.00
146.00
144.00
ROUTE 38
LEGEND
SW-7 SHALLOW MONITORING WELL
DW-1 DEEP MONITORING WELL
147.30 GROUND-WATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL
144.00 GROUND-WATER ELEVATION CONTOUR
GENERAL DIRECTION OF GROUND-WATER FLOW
NOTE: DUE TO THE PRESENCE OF PERCHED WATER CONDITIONS IN THE SOUTHWESTERN PORTION OF THE SITE, DATA FROM SW-7 WAS NOT USED IN THE DEVELOPMENT OF WATER TABLE ELEVATION CONTOURS
FORENSIC ENVIRONMENTAL SERVICES, INC.
FIGURE 2-2
GROUND-WATER FLOW MAP (10/14/96)
SHALLOW TUTU AQUIFER
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
0
50
SCALE IN FEET
DRAWN BY: B.J.M. 9/11/96
APPROVED BY:
GWF1096.DWG



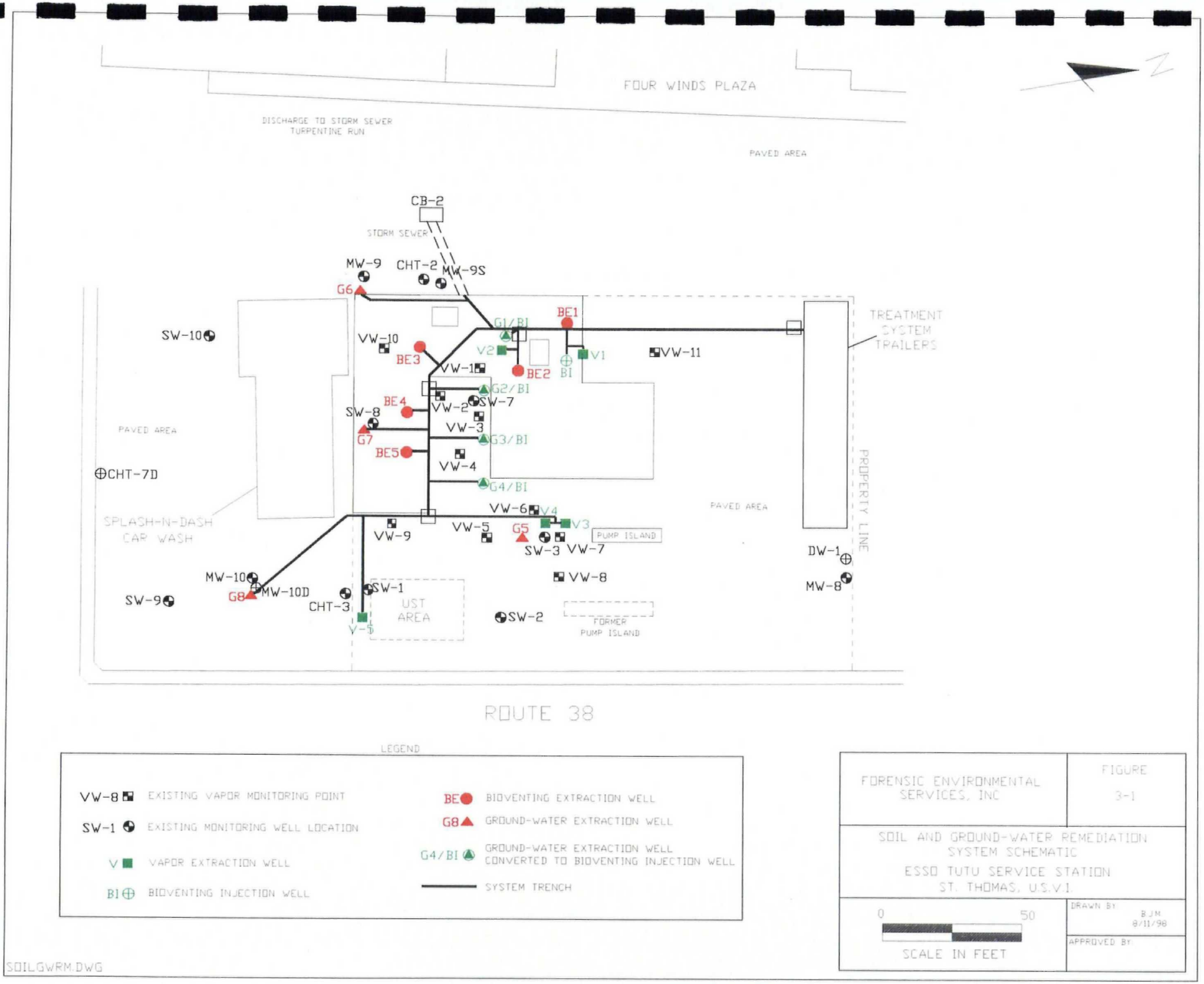
FOUR WINDS PLAZA
DRUG STORE
OIL/GREASE SEPARATOR (SOUTH OIL/WATER SEPARATOR)
PAVED AREA
INVESTIGATION TRENCH
"HOLDING TANK" (NORTH OIL/WATER SEPARATOR)
SS-6
SS-4
SS-5
SS-1
SS-3
SS-7
SS-8
SS-9
SPLASH-N-DASH CAR WASH
SS-2(a)
SS-1(a)
TUTU ESSO SERVICE STATION
PAVED AREA
PAVED AREA
PROPERTY LINE
PUMP ISLAND
FORMER PUMP ISLAND
UST AREA
ROUTE 38
LEGEND
SS-6 ■ SOIL SAMPLE LOCATION
FORENSIC ENVIRONMENTAL SERVICES, INC.
FIGURE 2-3
SAMPLE LOCATION MAP
OIL/WATER SEPARATORS (1993)
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
0
50
SCALE IN FEET
DRAWN BY: B.J.M. 9/11/96
APPROVED BY:
SSLOWS.DWG

LEGEND

- MW-8 SHALLOW MONITORING WELL
- MW-10D DEEP MONITORING WELL
- B-9 SOIL BORING LOCATION

FORENSIC ENVIRONMENTAL SERVICES, INC.	FIGURE 2-4
SOIL BORING AND MONITORING WELL LOCATION MAP (1996) ESSO TUTU SERVICE STATION ST. THOMAS, U.S.V.I.	
0 50 SCALE IN FEET	DRAWN BY: B.J.M. 9/11/96 APPROVED BY:

SBMW1996.DWG



FOUR WINDS PLAZA
DISCHARGE TO STORM SEWER TURPENTINE RUN
PAVED AREA
CB-2
STORM SEWER
MW-9
CHT-2
MW-9S
G6
G1/BI
BE1
TREATMENT SYSTEM TRAILERS
SW-10
VW-10
BE3
V2
VW-1
BE2
BI
V1
VW-11
G2/BI
BE4
SW-8
VW-2
SW-7
VW-3
G7
G3/BI
PAVED AREA
BE5
VW-4
CHT-7D
G4/BI
PROPERTY LINE
PAVED AREA
SPLASH-N-DASH CAR WASH
VW-6
V4
V3
VW-9
VW-5
G5
PUMP ISLAND
SW-3
VW-7
DW-1
MW-10
VW-8
MW-8
G8
MW-10D
SW-1
SW-9
CHT-3
UST AREA
SW-2
FORMER PUMP ISLAND
V-5
ROUTE 38
LEGEND
VW-8 EXISTING VAPOR MONITORING POINT
SW-1 EXISTING MONITORING WELL LOCATION
V VAPOR EXTRACTION WELL
BI BIOVENTING INJECTION WELL
BE BIOVENTING EXTRACTION WELL
G8 GROUND-WATER EXTRACTION WELL
G4/BI GROUND-WATER EXTRACTION WELL CONVERTED TO BIOVENTING INJECTION WELL
SYSTEM TRENCH
FORENSIC ENVIRONMENTAL SERVICES, INC
FIGURE 3-1
SOIL AND GROUND-WATER REMEDIATION SYSTEM SCHEMATIC
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
0
50
SCALE IN FEET
DRAWN BY BJM 8/11/98
APPROVED BY
SOILGWRM.DWG

LEGEND

VW-8	EXISTING VAPOR MONITORING POINT	BE	BIOVENTING EXTRACTION WELL
SW-1	EXISTING MONITORING WELL LOCATION	G8	GROUND-WATER EXTRACTION WELL
V	VAPOR EXTRACTION WELL	G4/BI	GROUND-WATER EXTRACTION WELL CONVERTED TO BIOVENTING INJECTION WELL
BI	BIOVENTING INJECTION WELL		IMPACTED SOIL AREA (VOLATILE ORGANIC COMPOUNDS AND TPH ABOVE SSLs)
	AREA OF VAPOR/BIO EXTRACTION WELL INFLUENCE		

FORENSIC ENVIRONMENTAL SERVICES, INC.

FIGURE 3-2

APPROXIMATE AREA OF SOIL IMPACT ABOVE SSLs

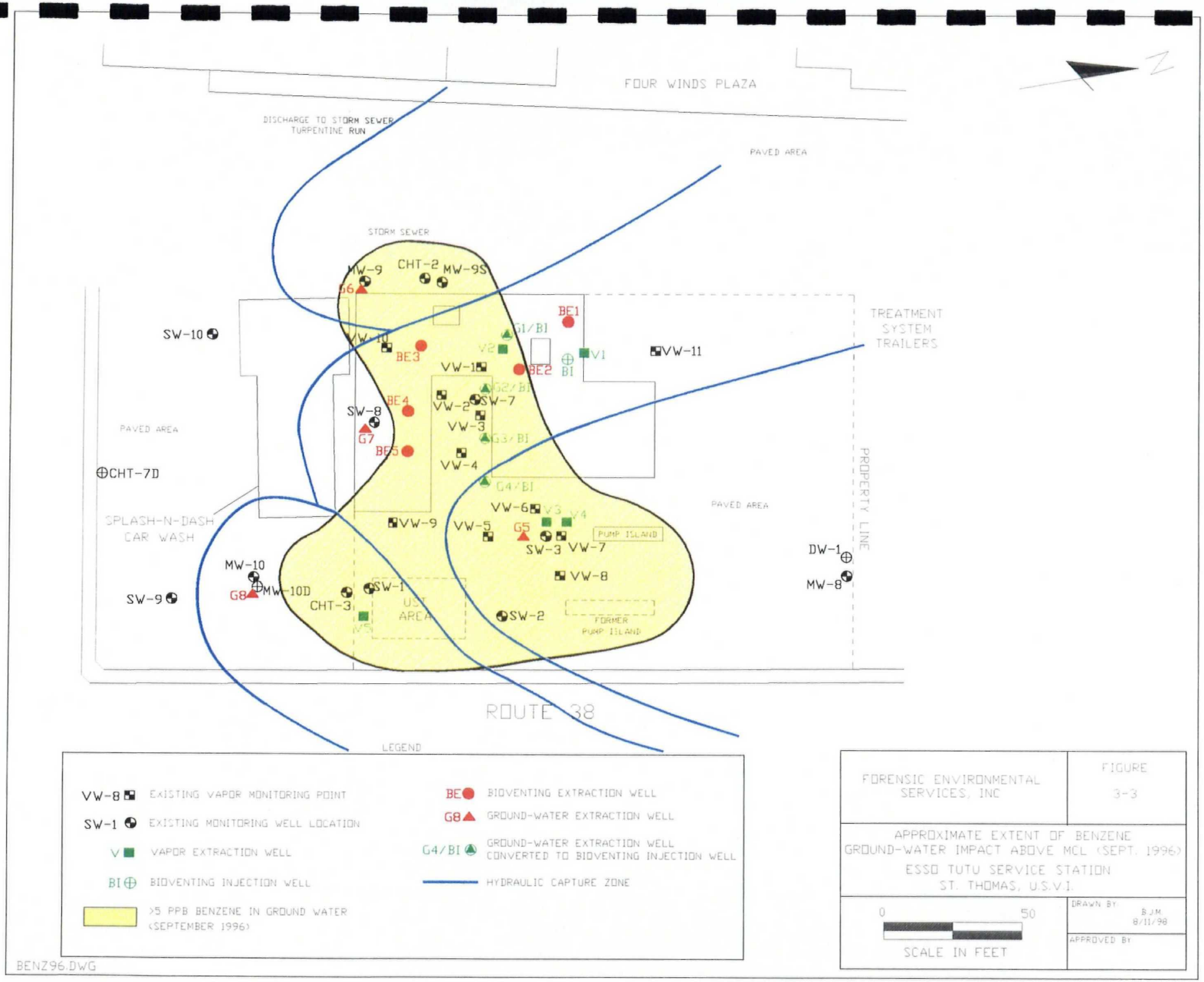
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.

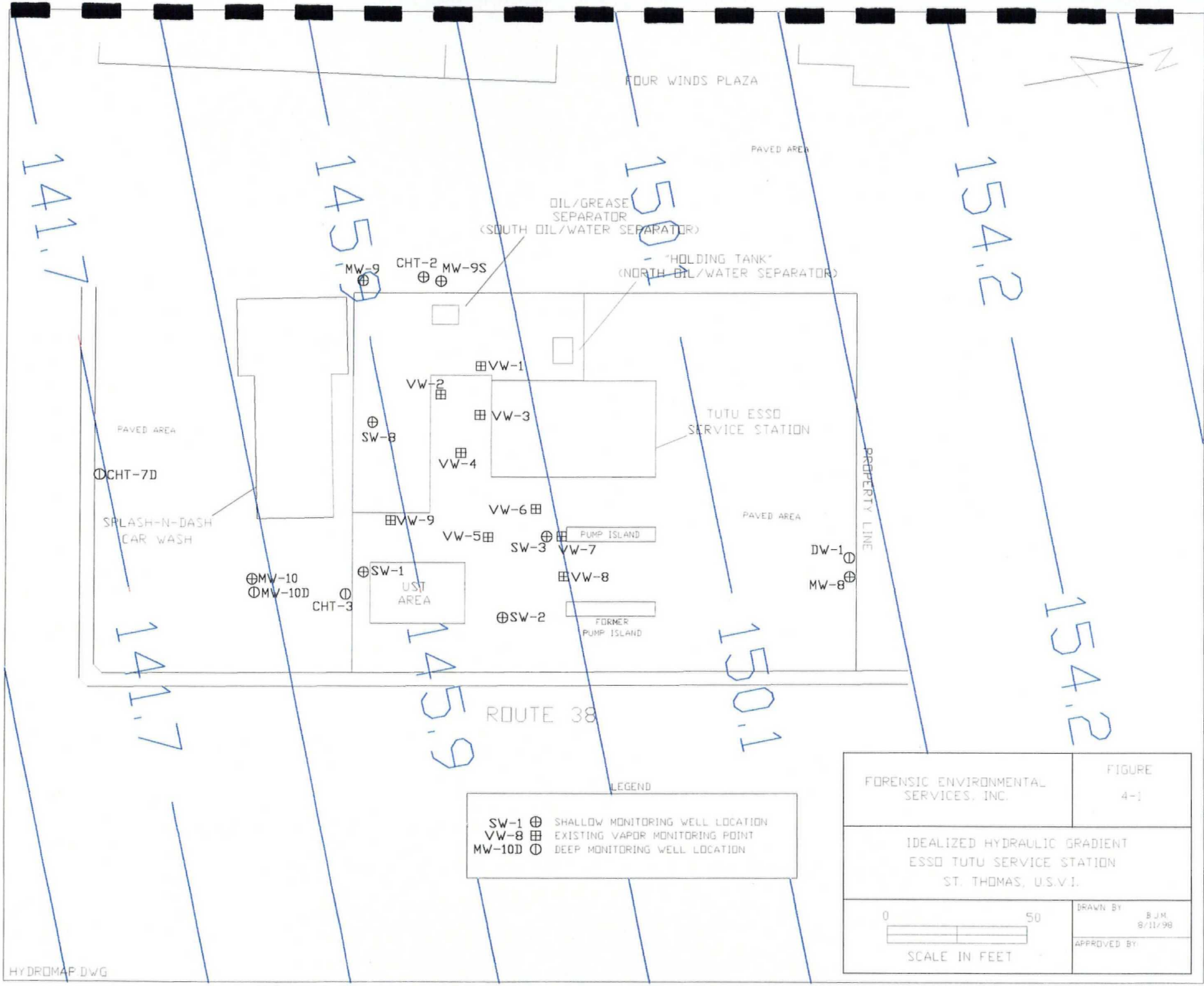
0 50
SCALE IN FEET

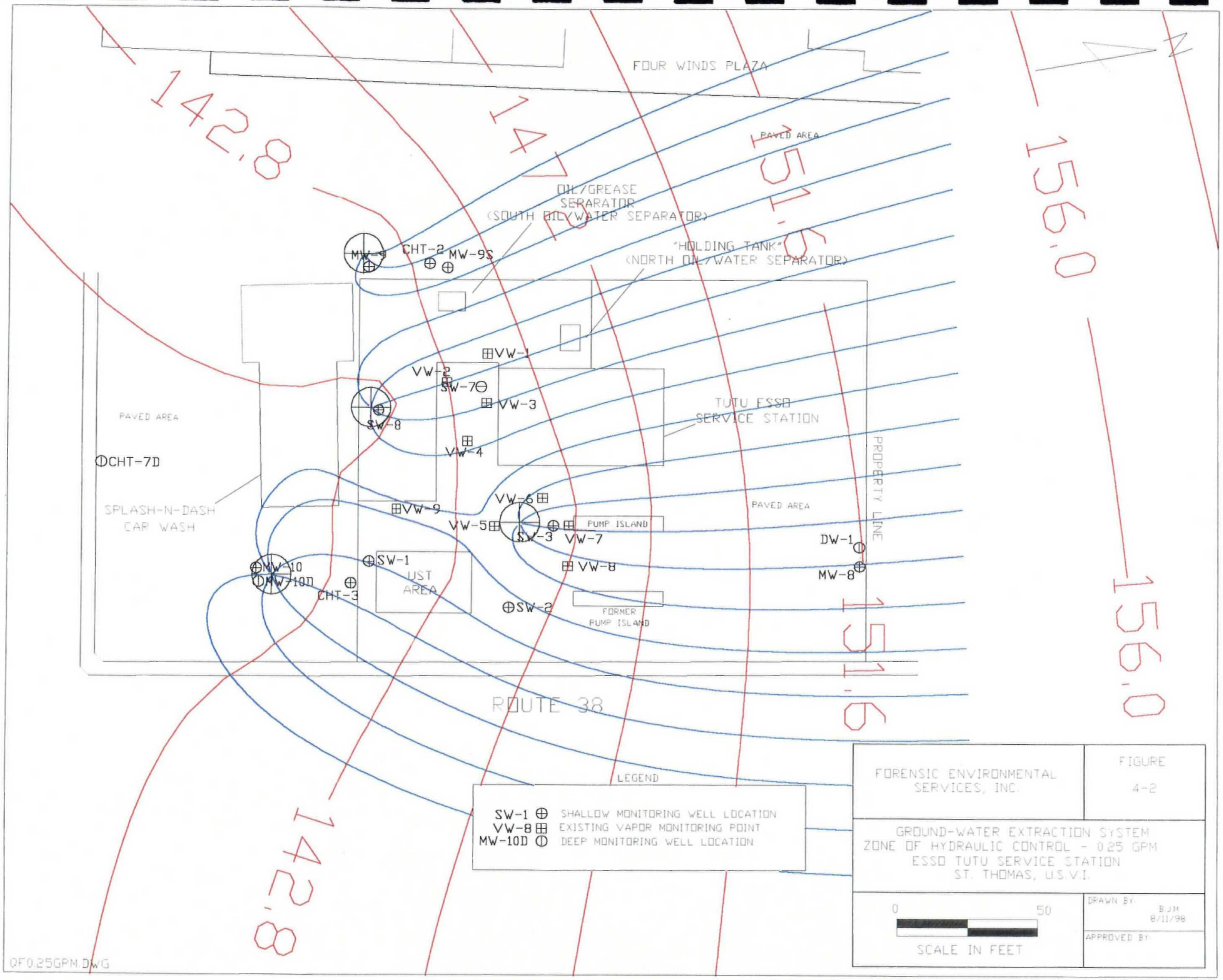
DRAWN BY: BJM 8/11/98

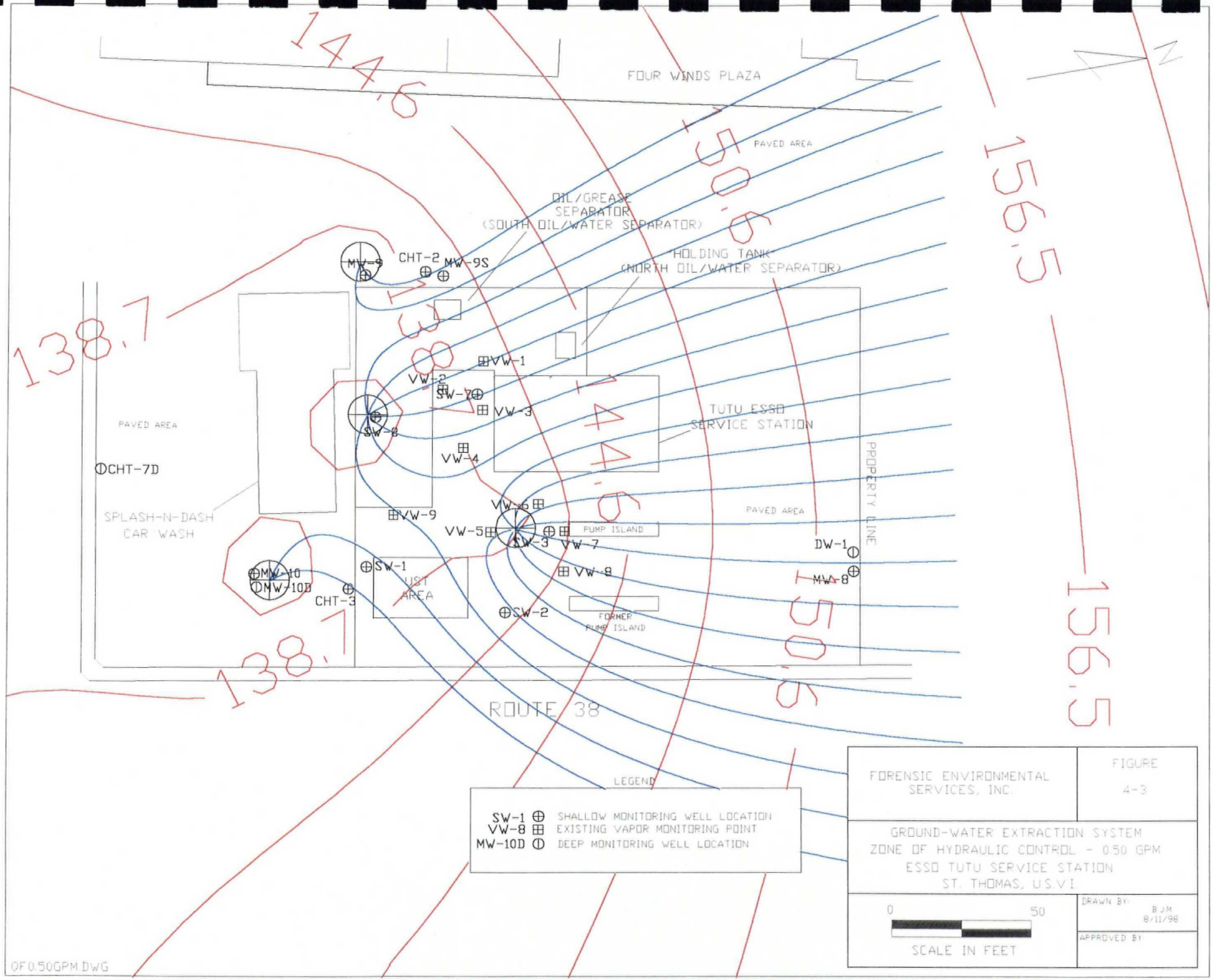
APPROVED BY:

SOILIMPK.DWG


FOUR WINDS PLAZA
DISCHARGE TO STORM SEWER TURPENTINE RUN
PAVED AREA
STORM SEWER
MW-9
CHT-2
MW-9S
G6
BE1
G1/BI
V2
V1
BI
VW-11
TREATMENT SYSTEM TRAILERS
SW-10
VW-10
BE3
VW-1
BE2
G2/BI
VW-2
SW-7
BE4
SW-8
VW-3
G7
G3/BI
BE5
PAVED AREA
CHT-7D
VW-4
G4/BI
PROPERTY LINE
VW-6
V3
V4
PAVED AREA
SPLASH-N-DASH CAR WASH
VW-9
VW-5
G5
PUMP ISLAND
SW-3
VW-7
DW-1
MW-10
VW-8
MW-8
SW-9
G8
MW-10D
CHT-3
SW-1
UST AREA
V5
SW-2
FORMER PUMP ISLAND
ROUTE 38
LEGEND
VW-8 EXISTING VAPOR MONITORING POINT
SW-1 EXISTING MONITORING WELL LOCATION
V VAPOR EXTRACTION WELL
BI BIOVENTING INJECTION WELL
>5 PPB BENZENE IN GROUND WATER (SEPTEMBER 1996)
BE BIOVENTING EXTRACTION WELL
G8 GROUND-WATER EXTRACTION WELL
G4/BI GROUND-WATER EXTRACTION WELL CONVERTED TO BIOVENTING INJECTION WELL
HYDRAULIC CAPTURE ZONE
FORENSIC ENVIRONMENTAL SERVICES, INC
FIGURE 3-3
APPROXIMATE EXTENT OF BENZENE GROUND-WATER IMPACT ABOVE MCL (SEPT. 1996)
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
0
50
SCALE IN FEET
DRAWN BY: BJM 8/11/98
APPROVED BY:
BENZ96.DWG


FOUR WINDS PLAZA
PAVED AREA
141.7
145.9
150.1
154.2
OIL/GREASE SEPARATOR (SOUTH OIL/WATER SEPARATOR)
"HOLDING TANK" (NORTH OIL/WATER SEPARATOR)
MW-9
CHT-2
MW-9S
VW-1
VW-2
VW-3
SW-8
VW-4
TUTU ESSO SERVICE STATION
PAVED AREA
CHT-7D
PROPERTY LINE
SPLASH-N-DASH CAR WASH
VW-6
VW-9
VW-5
SW-3
VW-7
PUMP ISLAND
PAVED AREA
DW-1
MW-8
SW-1
MW-10
MW-10D
CHT-3
UST AREA
VW-8
SW-2
FORMER PUMP ISLAND
ROUTE 38
LEGEND
SW-1 SHALLOW MONITORING WELL LOCATION
VW-8 EXISTING VAPOR MONITORING POINT
MW-10D DEEP MONITORING WELL LOCATION
FORENSIC ENVIRONMENTAL SERVICES, INC.
FIGURE 4-1
IDEALIZED HYDRAULIC GRADIENT
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
0
50
SCALE IN FEET
DRAWN BY B.J.M. 8/11/98
APPROVED BY
HYDROMAP.DWG

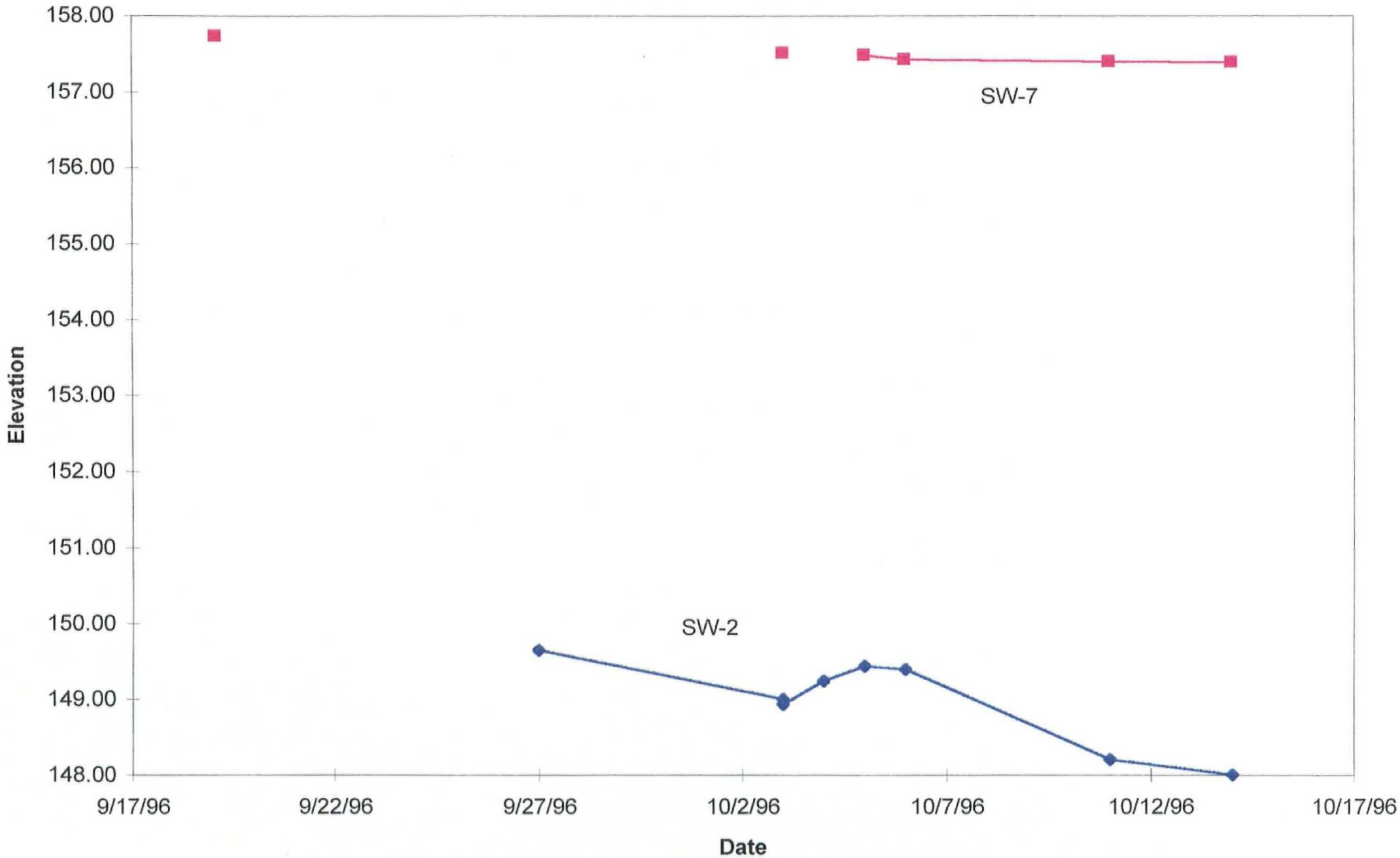

FOUR WINDS PLAZA
142.8
147
151.6
156.0
PAVED AREA
OIL/GREASE SEPARATOR (SOUTH OIL/WATER SEPARATOR)
"HOLDING TANK" (NORTH OIL/WATER SEPARATOR)
MW-9
CHT-2
MW-9S
VW-1
VW-2
SW-7
VW-3
SW-8
VW-4
TUTU ESSO SERVICE STATION
PROPERTY LINE
CHT-7D
SPLASH-N-DASH CAR WASH
VW-6
VW-9
VW-5
SW-3
VW-7
PUMP ISLAND
DW-1
MW-8
MW-10
MW-10D
SW-1
UST AREA
CHT-3
VW-8
SW-2
FORMER PUMP ISLAND
ROUTE 38
LEGEND
SW-1 SHALLOW MONITORING WELL LOCATION
VW-8 EXISTING VAPOR MONITORING POINT
MW-10D DEEP MONITORING WELL LOCATION
FORENSIC ENVIRONMENTAL SERVICES, INC.
FIGURE 4-2
GROUND-WATER EXTRACTION SYSTEM
ZONE OF HYDRAULIC CONTROL - 0.25 GPM
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
0
50
SCALE IN FEET
DRAWN BY: BJM 8/11/98
APPROVED BY:
QF0.25GPM.DWG


FOUR WINDS PLAZA
PAVED AREA
144.6
150.6
156.5
138.7
OIL/GREASE SEPARATOR (SOUTH OIL/WATER SEPARATOR)
"HOLDING TANK" (NORTH OIL/WATER SEPARATOR)
MW-9
CHT-2
MW-9S
VW-1
VW-2
SW-7
VW-3
SW-8
VW-4
TUTU ESSO SERVICE STATION
PROPERTY LINE
PAVED AREA
CHT-7D
SPLASH-N-DASH CAR WASH
VW-6
VW-9
VW-5
SW-3
VW-7
PUMP ISLAND
DW-1
MW-8
SW-1
UST AREA
MW-10
MW-10D
CHT-3
VW-8
SW-2
FORMER PUMP ISLAND
ROUTE 38
LEGEND
SW-1 SHALLOW MONITORING WELL LOCATION
VW-8 EXISTING VAPOR MONITORING POINT
MW-10D DEEP MONITORING WELL LOCATION
FORENSIC ENVIRONMENTAL SERVICES, INC.
FIGURE 4-3
GROUND-WATER EXTRACTION SYSTEM
ZONE OF HYDRAULIC CONTROL - 0.50 GPM
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
0
50
SCALE IN FEET
DRAWN BY: BJM 8/11/98
APPROVED BY:
QF0.50GPM.DWG

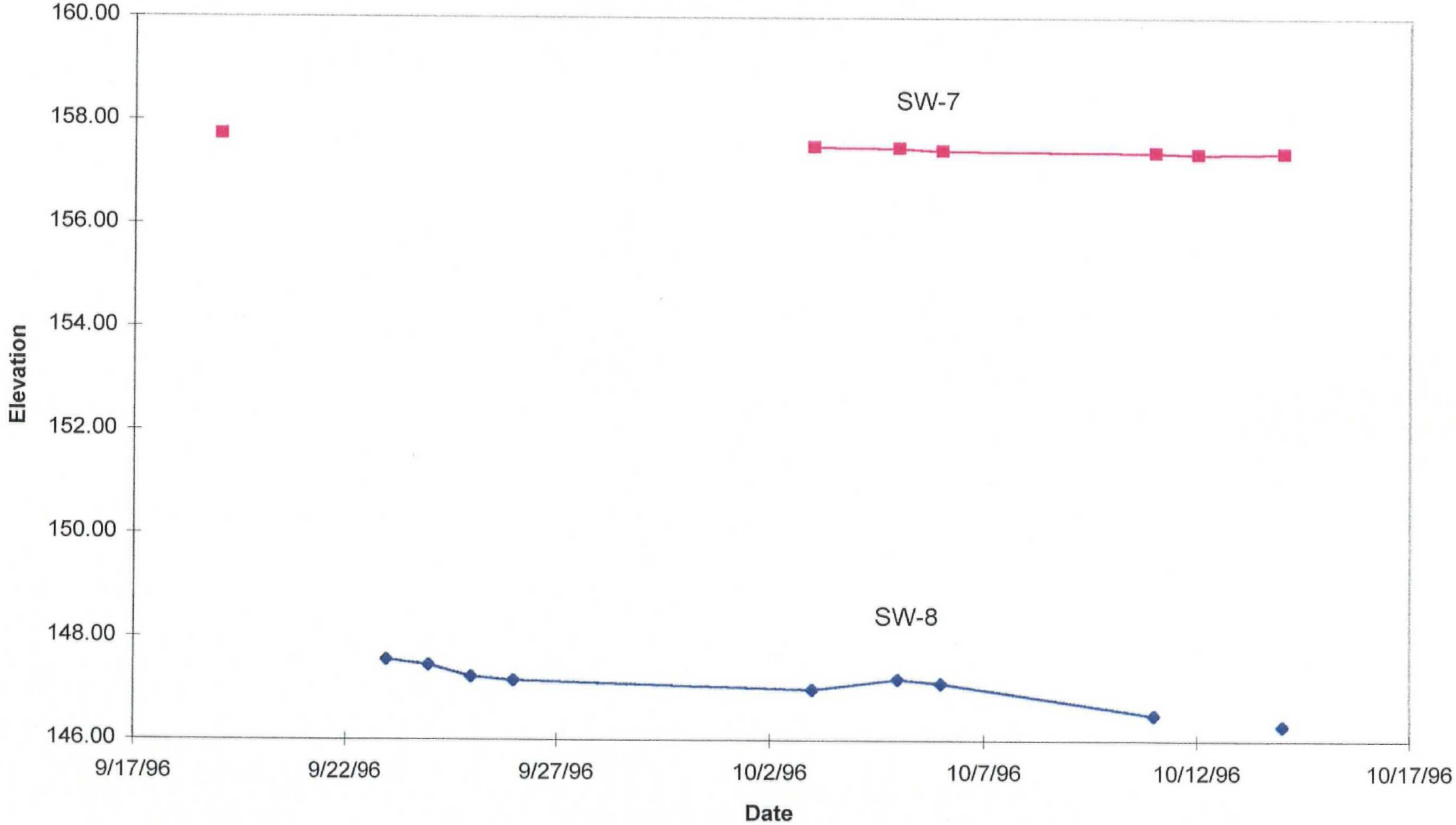
APPENDIX A
Calculations, Previous Investigative/Pilot Testing Results, and Miscellaneous Basis of Design Information

Monitoring Well Hydrographs

Ground-Water Elevation Data
Monitoring Wells SW-2 and SW-7
Esso Tutu Service Station
St. Thomas, U.S.V.I.

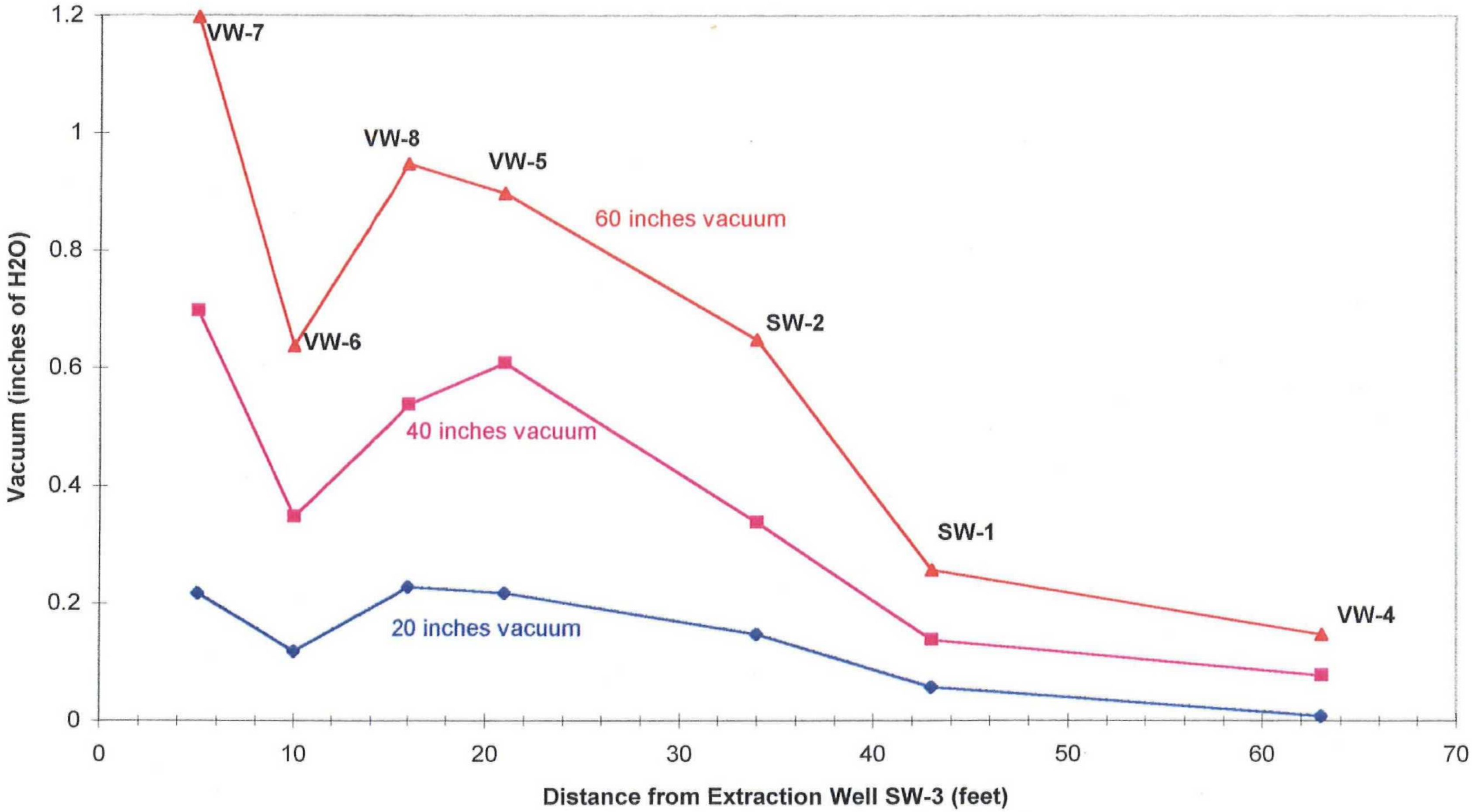


Ground-Water Elevation Data
Monitoring Wells SW-7 & SW-8
Esso Tutu Service Station
St. Thomas, U.S.V.I.

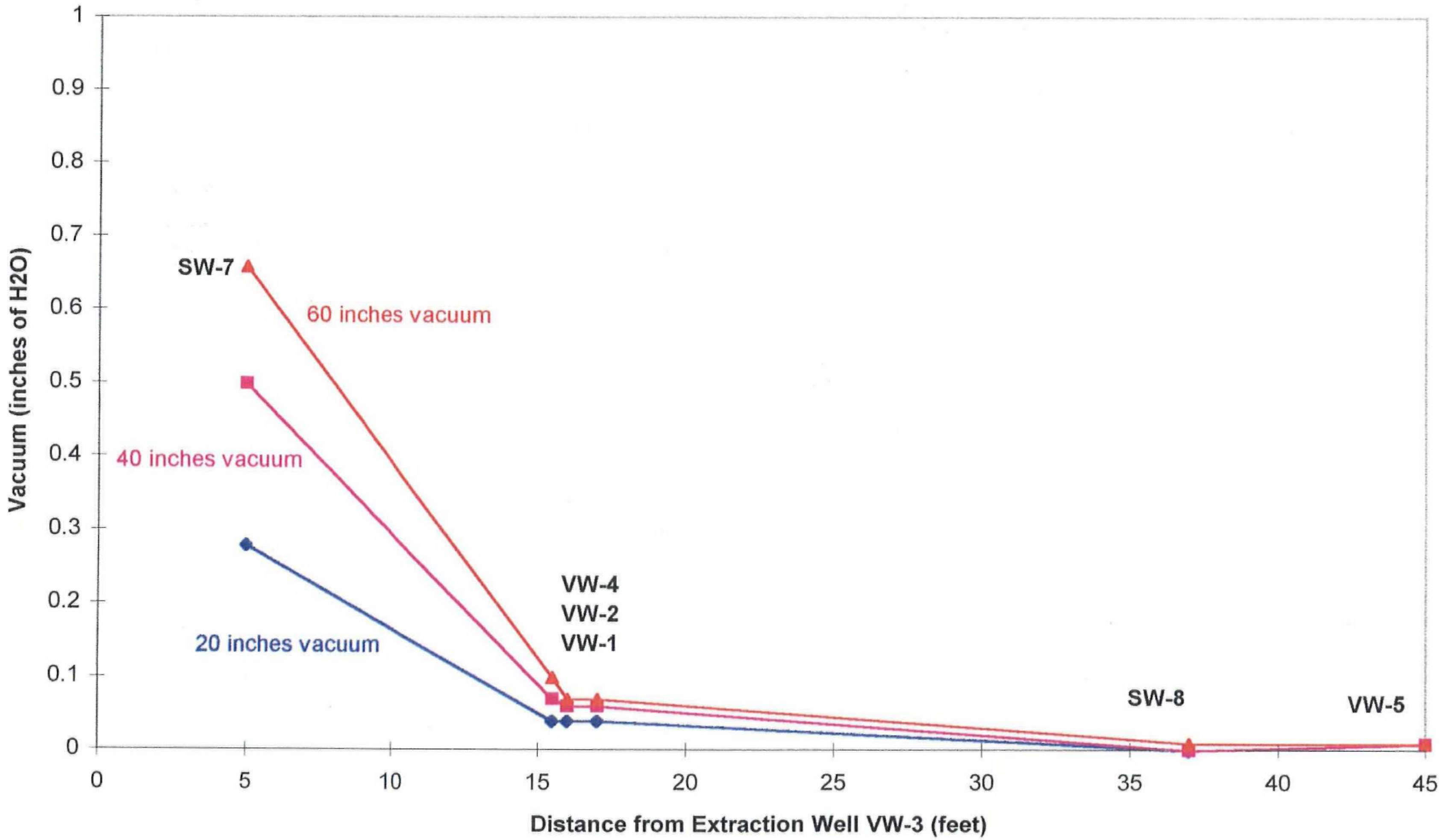


SVE Pilot Test Data

Soil Vapor Extraction Test-SW-3
Distance-Drawdown Graph
Esso Tutu Service Station
St. Thomas, U.S.V.I.



Soil Vapor Extraction Test-VW-3
Distance-Drawdown Graph
Esso Tutu Service Station
St. Thomas, U.S.V.I.

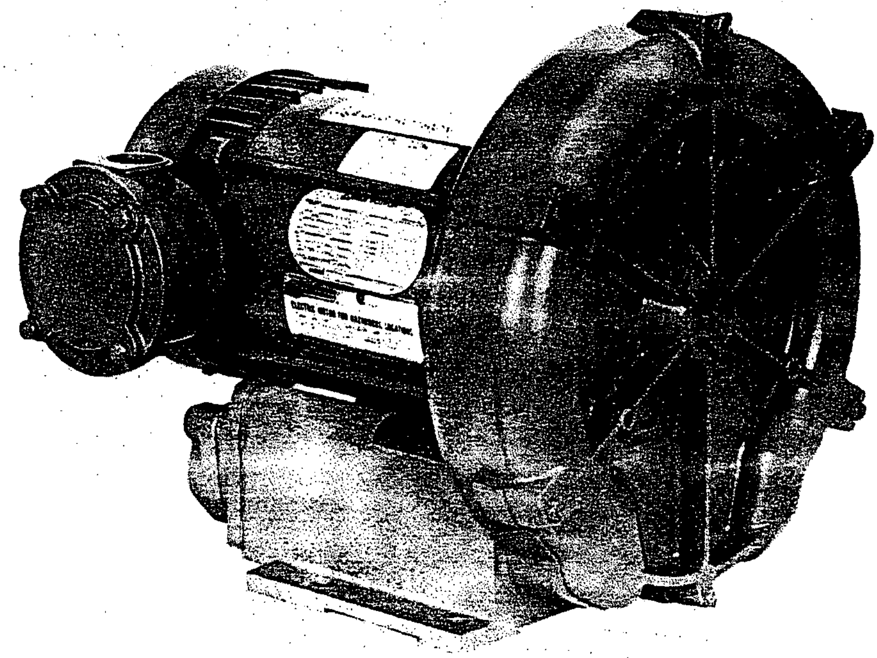


EN 454
Explosion-Proof Regenerative Blower

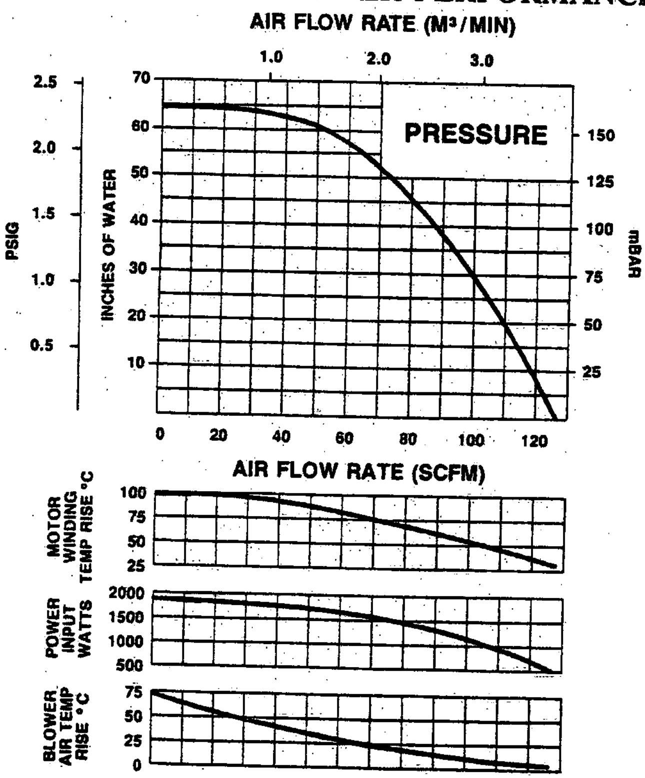
FEATURES
- Manufactured in the USA
- Maximum flow: 127 SCFM
- Maximum pressure: 65″ WG
- Maximum vacuum: 59″ WG
- Standard motor: 1.5 HP
- Blower construction — cast aluminum housing, cover, impeller & manifold; cast iron flanges
- UL & CSA approved motors for Class I, Group D atmospheres
- Sealed blower assembly
- Quiet operation within OSHA standards

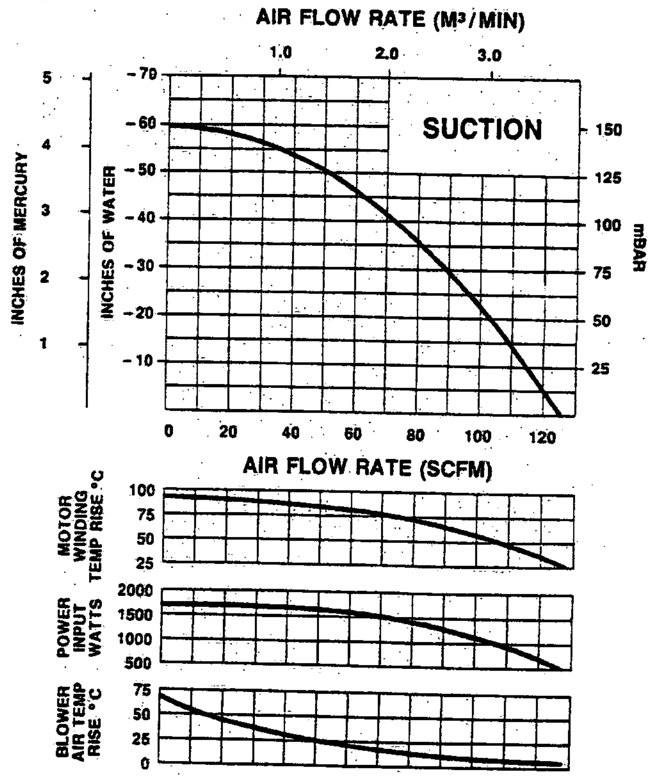
OPTIONS
- TEFC motors
- 50 Hz motors
- International voltages
- Other HP motors
- Corrosion resistant surface treatments
- Remote drive (motorless) models

ACCESSORIES
- Moisture separators
- Explosion-proof motor starters
- Inline & inlet filters
- Vacuum & pressure gauges
- Relief valves
- External mufflers



BLOWER PERFORMANCE AT STANDARD CONDITIONS





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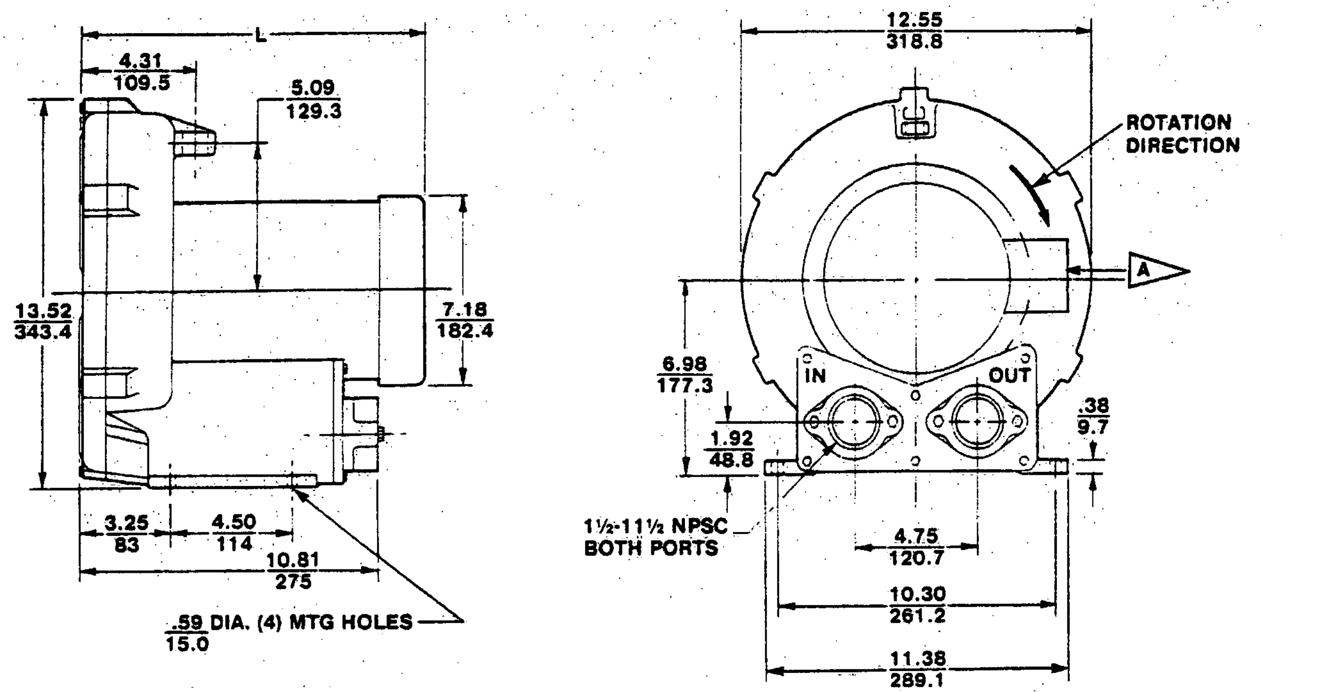
EN 454
Explosion-Proof Regenerative Blower



DIMENSIONS:	IN / MM
TOLERANCES:	.XX ± .06 / 1.5
(UNLESS OTHERWISE NOTED)	

MODEL	L (IN)±.3	L (MM)±8
EN454W58L	17.51	445
EN454W72L	16.63	422

A: 0.75" NPT CONDUIT CONNECTION AT 12 O'CLOCK POSITION

SPECIFICATIONS

MODEL	EN454W58L		EN454W72L	
Part No.	038175		038176	
Motor Enclosure Type	Explosion-proof		Explosion-proof	
Horsepower	1.5		1.5	
Phase — Frequency	Single — 60 Hz		Three - 60 Hz	
Voltage [1]	115	208-230	230	460
Motor Nameplate Amps	17.7	9.35-8.85	4.5	2.25
Maximum Blower Amps [3]	19.4	9.7-9.0	4.8	2.4
Inrush Amps	96	48	32	16
Starter Size	1	0	00	00
Service Factor	1.0		1.0	
Thermal Protection [2]	Pilot Duty		Pilot Duty	
Bearing Type	Sealed, Ball		Sealed, Ball	
Shipping Weight	84 lb (38 kg)		78 lb (35 kg)	

BLOWER LIMITATIONS

Min. Flow @ Max. Suction	0 SCFM @ −59" WG	0 SCFM @ −59" WG
Min. Flow @ Max. Pressure	0 SCFM @ 65" WG	0 SCFM @ 65" WG

[1]All dual voltage 3 phase motors are factory tested and certified to operate on 200-230/400-460 VAC-3 ph-60 Hz. All dual voltage 1 phase motors are factory tested and certified to operate on 110-120/200-230 VAC-1 ph-60 Hz.
[2]Maximum operating temperatures: Motor winding temperature (winding rise plus ambient) should not exceed 140°C for Class F insulation or 120°C for Class B insulation. Blower outlet air temperature should not exceed 140°C (air temperature rise plus ambient).
[3]Corresponds to the performance point at which the blower and/or motor temperature rise reaches the limit of the thermal protection in the motor.

Specifications subject to change without notice. Please contact factory for specification updates.

Lancaster Laboratories
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LLI Sample No. AQ 2594947
Collected: 10/ 6/96 at 11:45 by BSM

Submitted: 10/ 8/96 Reported: 10/25/96
Discard: 11/ 5/96

VT Sample 2 Grab Tedlar Bag Sample

ESSO TUTU - St. Thomas, U.S.V.I.
VT--2 SDG#: ESS06-10

Account No: 08324
Forensic Environmental Service
623 N. Pottstown Pike, Ste. A
Exton PA 19341

P.O.
Rel.

AS RECEIVED

CAT NO.	ANALYSIS NAME	RESULTS	METHOD DETECTION LIMIT	UNITS
5695	TO-14 Form 1			See Page 2
6900	GC/MS Air TIC Form Upload			See Page 5
7869	TO 14 VOA Ext. List Tedlar	see form I		
7870	TO 14 VOA Ext List cont Tedlar	see form I		

1 COPY TO Forensic Environmental Service ATTN: Mr. Patrick O'Toole
1 COPY TO Data Package Group

Questions? Contact your Client Services Representative
Lisa M. Hetrick at (717) 656-2300
08:07:34 D 0002 10 127594 536655
0.00 00039000 ASR000

Respectfully Submitted
Michele McClarin, B.A.
Group Leader, GC/MS Volatiles

Lancaster Laboratories
A division of Thermo Analytical Inc.

VOLATILE ORGANICS IN AIR
TEDLAR BAG SAMPLE
ANALYSIS DATA SHEET

Sample No.:VT--2 Date Collected:10/06/96 Date Received:10/08/96
Lab Sample ID:2594947 Date Analyzed:10/11/96 Time Analyzed:19:45
Injection Volume: 250.0 cc Nominal Volume: 250 cc Dilution Factor: 100.0
Instrument ID:HP4508 Lab File ID:C:\HPCHEM\1\DATA\OCT11\1101015.D

CAS RN	COMPOUND NAME	CONCENTRATION (PPBV)	Q
115-07-1	Propene	20	U
75-71-8	Dichlorodifluoromethane	20	U
75-45-6	Chlorodifluoromethane	100	U
76-14-2	Freon 114	20	U
74-87-3	Chloromethane	20	U
75-01-4	Vinyl Chloride	20	U
106-99-0	1,3-Butadiene	100	U
74-83-9	Bromomethane	20	U
75-00-3	Chloroethane	20	U
75-43-4	Dichlorofluoromethane	20	U
593-60-2	Bromoethene	20	U
75-69-4	Trichlorofluoromethane	20	U
109-66-0	Pentane	260000	D
107-02-8	Acrolein	50	U
75-35-4	1,1-Dichloroethene	20	U
76-13-1	Freon 113	50	U
67-64-1	Acetone	100	U
74-88-4	Methyl Iodide	20	U
75-15-0	Carbon Disulfide	50	U
75-05-8	Acetonitrile	50	U
107-05-1	3-Chloropropene	20	U
75-09-2	Methylene Chloride	50	U
107-13-1	Acrylonitrile	50	U
156-60-5	trans-1,2-Dichloroethene	20	U
1634-04-4	Methyl t-Butyl Ether	20	U
110-54-3	Hexane	19000	D
75-34-3	1,1-Dichloroethane	20	U
108-05-4	Vinyl Acetate	20	U
156-59-2	cis-1,2-Dichloroethene	20	U
78-93-3	2-Butanone	50	U
141-78-6	Ethyl Acetate	20	U
96-33-3	Methyl Acrylate	20	U
67-66-3	Chloroform	20	U
71-55-6	1,1,1-Trichloroethane	20	U
56-23-5	Carbon Tetrachloride	20	U
107-06-2	1,2-Dichloroethane	20	U
71-43-2	Benzene	5500	D

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Respectfully Submitted
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See reverse side for explanation of symbols and abbreviations

2216 Rev. 5/01/96

Lancaster Laboratories
A division of Thermo Analytical Inc.

VOLATILE ORGANICS IN AIR
TEDLAR BAG SAMPLE
ANALYSIS DATA SHEET

Sample No.:VT--2 Date Collected:10/06/96 Date Received:10/08/96
ab Sample ID:2594947 Date Analyzed:10/11/96 Time Analyzed:19:45
jection Volume: 250.0 cc Nominal Volume: 250 cc Dilution Factor: 100.0
Instrument ID:HP4508 Lab File ID:C:\HPCHEM\1\DATA\OCT11\1101015.D

CAS RN	COMPOUND NAME	CONCENTRATION (PPBV)	Q
594-82-1	Isooctane	9200	D
142-82-5	Heptane	20	U
79-01-6	Trichloroethene	20	U
140-88-5	Ethyl Acrylate	20	U
78-87-5	1,2-Dichloropropane	20	U
80-62-6	Methyl Methacrylate	20	U
74-95-3	Dibromomethane	20	U
123-91-1	1,4-Dioxane	20	U
75-27-4	Bromodichloromethane	20	U
10061-01-5	cis-1,3-Dichloropropene	20	U
108-10-1	4-Methyl-2-Pentanone	50	U
108-88-3	Toluene	920	D
111-65-9	Octane	1300	D
0061-02-6	trans-1,3-Dichloropropene	20	U
97-63-2	Ethyl Methacrylate	20	U
79-00-5	1,1,2-Trichloroethane	20	U
127-18-4	Tetrachloroethene	20	U
591-78-6	2-Hexanone	50	U
124-48-1	Dibromochloromethane	20	U
106-93-4	1,2-Dibromoethane	20	U
108-90-7	Chlorobenzene	20	U
630-20-6	1,1,1,2-Tetrachloroethane	20	U
100-41-4	Ethylbenzene	12000	D
1330-20-7	m/p-Xylene	1100	D
95-47-6	o-Xylene	300	D
100-42-5	Styrene	20	U
75-25-2	Bromoform	20	U
98-82-8	Cumene	4300	D
79-34-5	1,1,2,2-Tetrachloroethane	20	U
96-18-4	1,2,3-Trichloropropane	20	U
108-86-1	Bromobenzene	20	U
622-96-8	4-Ethyltoluene	760	D
108-67-8	1,3,5-Trimethylbenzene	420	D
611-15-1	Alpha Methyl Styrene	20	U
95-63-6	1,2,4-Trimethylbenzene	1200	D
541-73-1	1,3-Dichlorobenzene	50	U
106-46-7	1,4-Dichlorobenzene	50	U

U = Compound was undetected at the specified limit of detection.
B = Compound was found in method blank. D = analysis of diluted sample.
J = Compound detected but below the limit of quantitation.
NOTE: Limits of quantitation were raised due to th of volatile organic compounds in this sample.

Respectfully Submitted
Michele McClarin, B.A.
Group Leader, GC/MS Volatiles

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See reverse side for explanation of symbols and abbreviations

Lancaster Laboratories
A division of Thermo Analytical Inc.

VOLATILE ORGANICS IN AIR
TEDLAR BAG SAMPLE
ANALYSIS DATA SHEET

Sample No.:VT--2 Date Collected:10/06/96 Date Received:10/08/96
Lab Sample ID:2594947 Date Analyzed:10/11/96 Time Analyzed:19:45
Injection Volume: 250.0 cc Nominal Volume: 250 cc Dilution Factor: 100.0
Instrument ID:HP4508 Lab File ID:C:\HPCHEM\1\DATA\OCT11\1101015.D

CAS RN	COMPOUND NAME	CONCENTRATION (PPBV)	Q
100-44-7	Benzyl Chloride	20	U
95-50-1	1,2-Dichlorobenzene	50	U
67-72-1	Hexachloroethane	20	U
120-82-1	1,2,4-Trichlorobenzene	100	U
87-68-3	Hexachlorobutadiene	50	U

U = Compound was undetected at the specified limit of detection.
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Respectfully Submitted
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Lancaster Laboratories
A division of Thermo Analytical Inc.

VOLATILE ORGANICS IN AIR
TEDLAR BAG SAMPLE
TENTATIVELY IDENTIFIED COMPOUNDS

ple No.:VT--2 Date Collected:10/06/96 Date Received:10/08/96
ab Sample ID:2594947 Date Analyzed:10/11/96 Time Analyzed:19:45
ection Volume: 250.0 cc Nominal Volume: 250 cc Dilution Factor: 100.0
trument ID:HP4508 Lab File ID:C:\HPCHEM\1\DATA\OCT11\1101015.D
UNITS = PPBV

CAS RN	COMPOUND NAME	R.T.	ESTIMATED CONCENTRATION	Q
75285	Isobutane	6.93	4900	J
106978	Butane	7.37	8600	J
78784	Butane, 2-methyl-	8.88	18000	J
	Unknown	12.22	3300	J
109671	1-Pentene	12.38	2400	J
96140	Pentane, 3-methyl-	12.83	8100	J
565593	Pentane, 2,3-dimethyl-	16.26	3400	J
589344	Hexane, 3-methyl-	16.43	2500	J
589435	Hexane, 2,4-dimethyl-	18.49	3900	J
563166	Hexane, 3,3-dimethyl-	18.85	2400	J

B = Compound was found in method blank. D = analysis of diluted sample.
= Estimated concentration assuming identical response factor to that of the internal standard with retention time closest to the TIC.

Respectfully Submitted
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Group Leader, GC/MS Volatiles

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See reverse side for explanation of symbols and abbreviations

2216 Rev. 5/01/96

Lancaster Laboratories
A division of Thermo Analytical Inc.

LLI Sample No. AQ 2594949
Collected: 10/ 6/96 at 04:06 by BSM

Submitted: 10/ 8/96 Reported: 10/25/96
Discard: 11/ 5/96

VT Sample 4 Grab Tedlar Bag Sample

ESSO TUTU - St. Thomas, U.S.V.I.
VT--4 SDG#: ESS06-12*

Account No: 08324
Forensic Environmental Service
623 N. Pottstown Pike, Ste. A
Exton PA 19341

P.O.
Rel.

CAT NO.	ANALYSIS NAME	AS RECEIVED RESULTS	METHOD DETECTION LIMIT	UNITS
5695	TO-14 Form 1			See Page 2
6900	GC/MS Air TIC Form Upload			See Page 5
7869	TO 14 VOA Ext. List Tedlar	see form I		
7870	TO 14 VOA Ext List cont Tedlar	see form I		

1 COPY TO Forensic Environmental Service ATTN: Mr. Patrick O'Toole
1 COPY TO Data Package Group

Questions? Contact your Client Services Representative
Lisa M. Hetrick at (717) 656-2300
08:09:47 D 0002 10 127594 536655
0.00 00039000 ASR000

Respectfully Submitted
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VOLATILE ORGANICS IN AIR
TEDLAR BAG SAMPLE
ANALYSIS DATA SHEET

Sample No.:VT--4 | Date Collected:10/06/96 | Date Received:10/08/96
Lab Sample ID:2594949 | Date Analyzed:10/12/96 | Time Analyzed:01:33
Injection Volume: 50.0 cc | Nominal Volume: 250 cc | Dilution Factor: 5.0
Instrument ID:HP4508 | Lab File ID:C:\HPCHEM\1\DATA\OCT11\1801022.D

CAS RN	COMPOUND NAME	CONCENTRATION (PPBV)	Q
115-07-1	Propene	1	U
75-71-8	Dichlorodifluoromethane	1	U
75-45-6	Chlorodifluoromethane	5	U
76-14-2	Freon 114	1	U
74-87-3	Chloromethane	1	U
75-01-4	Vinyl Chloride	1	U
106-99-0	1,3-Butadiene	5	U
74-83-9	Bromomethane	1	U
75-00-3	Chloroethane	1	U
75-43-4	Dichlorofluoromethane	1	U
593-60-2	Bromoethene	1	U
75-69-4	Trichlorofluoromethane	1	U
109-66-0	Pentane	100000	D
107-02-8	Acrolein	2	U
75-35-4	1,1-Dichloroethene	1	U
76-13-1	Freon 113	6	D
67-64-1	Acetone	5	U
74-88-4	Methyl Iodide	1	U
75-15-0	Carbon Disulfide	2	U
75-05-8	Acetonitrile	2	U
107-05-1	3-Chloropropene	1	U
75-09-2	Methylene Chloride	2	U
107-13-1	Acrylonitrile	2	U
156-60-5	trans-1,2-Dichloroethene	1	U
1634-04-4	Methyl t-Butyl Ether	1	U
110-54-3	Hexane	7700	D
75-34-3	1,1-Dichloroethane	1	U
108-05-4	Vinyl Acetate	1	U
156-59-2	cis-1,2-Dichloroethene	1	U
78-93-3	2-Butanone	2	U
141-78-6	Ethyl Acetate	1	U
96-33-3	Methyl Acrylate	1	U
67-66-3	Chloroform	1	U
71-55-6	1,1,1-Trichloroethane	1	U
56-23-5	Carbon Tetrachloride	1	U
107-06-2	1,2-Dichloroethane	1	U
71-43-2	Benzene	260	D

U = Compound was undetected at the specified limit of detection.
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NOTE: Limits of quantitation were raised due to the high concentration of volatile organic compounds in this sample.

Respectfully Submitted
Michele McClarin, B.A.
Group Leader, GC/MS Volatiles

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Lancaster Laboratories
A division of Thermo Analytical Inc.

VOLATILE ORGANICS IN AIR
TEDLAR BAG SAMPLE
ANALYSIS DATA SHEET

Sample No.:VT--4 | Date Collected:10/06/96 | Date Received:10/08/96
Lab Sample ID:2594949 | Date Analyzed:10/12/96 | Time Analyzed:01:33
Injection Volume: 50.0 cc | Nominal Volume: 250 cc | Dilution Factor: 5.0
Instrument ID:HP4508 | Lab File ID:C:\HPCHEM\1\DATA\OCT11\1801022.D

CAS RN	COMPOUND NAME	CONCENTRATION (PPBV)	Q
594-82-1	Isooctane	3900	D
142-82-5	Heptane	200	D
79-01-6	Trichloroethene	29	D
140-88-5	Ethyl Acrylate	1	U
78-87-5	1,2-Dichloropropane	1	U
80-62-6	Methyl Methacrylate	1	U
74-95-3	Dibromomethane	1	U
123-91-1	1,4-Dioxane	1	U
75-27-4	Bromodichloromethane	1	U
10061-01-5	cis-1,3-Dichloropropene	1	U
108-10-1	4-Methyl-2-Pentanone	2	U
108-88-3	Toluene	11	D
111-65-9	Octane	1	U
0061-02-6	trans-1,3-Dichloropropene	1	U
7-63-2	Ethyl Methacrylate	1	U
79-00-5	1,1,2-Trichloroethane	1	U
127-18-4	Tetrachloroethene	230	D
591-78-6	2-Hexanone	2	U
124-48-1	Dibromochloromethane	1	U
106-93-4	1,2-Dibromoethane	1	U
108-90-7	Chlorobenzene	1	U
630-20-6	1,1,1,2-Tetrachloroethane	1	U
100-41-4	Ethylbenzene	44	D
1330-20-7	m/p-Xylene	6	D
95-47-6	o-Xylene	8	D
100-42-5	Styrene	1	U
75-25-2	Bromoform	1	U
98-82-8	Cumene	41	D
79-34-5	1,1,2,2-Tetrachloroethane	1	U
96-18-4	1,2,3-Trichloropropane	1	U
108-86-1	Bromobenzene	1	U
622-96-8	4-Ethyltoluene	3	D
108-67-8	1,3,5-Trimethylbenzene	2	D
611-15-1	Alpha Methyl Styrene	1	U
95-63-6	1,2,4-Trimethylbenzene	7	D
541-73-1	1,3-Dichlorobenzene	2	U
106-46-7	1,4-Dichlorobenzene	2	U

U = Compound was undetected at the specified limit of detection.
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J = Compound detected but below the limit of quantitation.
NOTE: Limits of quantitation were raised due to th
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Respectfully Submitted
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See reverse side for explanation of symbols and abbreviations

Lancaster Laboratories
A division of Thermo Analytical Inc.

VOLATILE ORGANICS IN AIR
TEDLAR BAG SAMPLE
ANALYSIS DATA SHEET

Sample No.:VT--4 Date Collected:10/06/96 Date Received:10/08/96
Sample ID:2594949 Date Analyzed:10/12/96 Time Analyzed:01:33
ection Volume: 50.0 cc Nominal Volume: 250 cc Dilution Factor: 5.0
nstrument ID:HP4508 Lab File ID:C:\HPCHEM\1\DATA\OCT11\1801022.D

CAS RN	COMPOUND NAME	CONCENTRATION (PPBV)	Q
100-44-7	Benzyl Chloride	1	U
95-50-1	1,2-Dichlorobenzene	2	U
67-72-1	Hexachloroethane	1	U
120-82-1	1,2,4-Trichlorobenzene	5	U
87-68-3	Hexachlorobutadiene	2	U

U = Compound was undetected at the specified limit of detection.
B = Compound was found in method blank. D = analysis of diluted sample.
J = Compound detected but below the limit of quantitation.
NOTE: Limits of quantitation were raised due to the high concentration of volatile organic compounds in this sample.

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See reverse side for explanation of symbols and abbreviations

2216 Rev. 5/01/96

Lancaster Laboratories

A division of Thermo Analytical Inc.

VOLATILE ORGANICS IN AIR
TEDLAR BAG SAMPLE
TENTATIVELY IDENTIFIED COMPOUNDS

mple No.:VT--4 Date Collected:10/06/96 Date Received:10/08/96
ab Sample ID:2594949 Date Analyzed:10/12/96 Time Analyzed:01:33
jection Volume: 50.0 cc Nominal Volume: 250 cc Dilution Factor: 5.0
strument ID:HP4508 Lab File ID:C:\HPCHEM\1\DATA\OCT11\1801022.D
UNITS = PPBV

CAS RN	COMPOUND NAME	R.T.	ESTIMATED CONCENTRATION	Q
75285	Isobutane	6.83	710	J D
106978	Butane	7.19	1200	J D
930187	Cyclopropane, 1,2-dimethyl-, cis-	10.42	480	J D
107835	Pentane, 2-methyl-	12.06	540	J D
96140	Pentane, 3-methyl-	12.67	290	J D
	Unknown aliphatic hydrocarbon -C9	16.87	300	J D
	Unknown aliphatic hydrocarbon -C8	18.41	320	J D
49622186	Decane, 3,3,4-trimethyl-	18.87	300	J D
565753	Pentane, 2,3,4-trimethyl-	19.23	400	J D
584941	Hexane, 2,3-dimethyl-	19.47	400	J D

B = Compound was found in method blank. D = analysis of diluted sample.
= Estimated concentration assuming identical response factor to that of the internal standard with retention time closest to the TIC.

Respectfully Submitted
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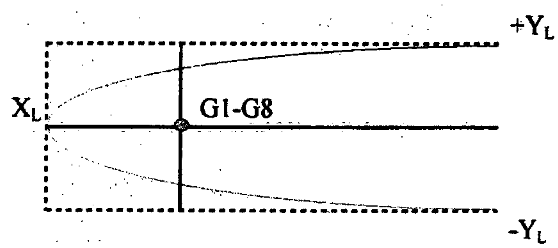
Pumping Test Pilot Test Data and Capture Zone Calculations

CAPTURE ZONE CALCULATIONS
FOR A WELL IN A UNIFORM FLOW FIELD (Todd, 1980)

$$Y_L = \pm \frac{Q}{2kbi}$$

$$X_L = \frac{Q}{2\pi kbi}$$



hydraulic conductivity	k =	0.144 feet/day		
saturated aquifer thickness	b =	80 feet (unconfined)		
hydraulic gradient	i =	0.04		
flow rate (in gallons	Q =	0.25 gpm	=	48 ft^3/day
per minute)		0.5 gpm	=	96 ft^3/day
		1.0 gpm	=	192 ft^3/day

@ 0.25 gpm $$Y_L = \pm \frac{48}{(2)*(0.144)*(80)*(0.04)} = \pm 52 \text{ feet} \qquad Y_L = 104 \text{ feet}$$

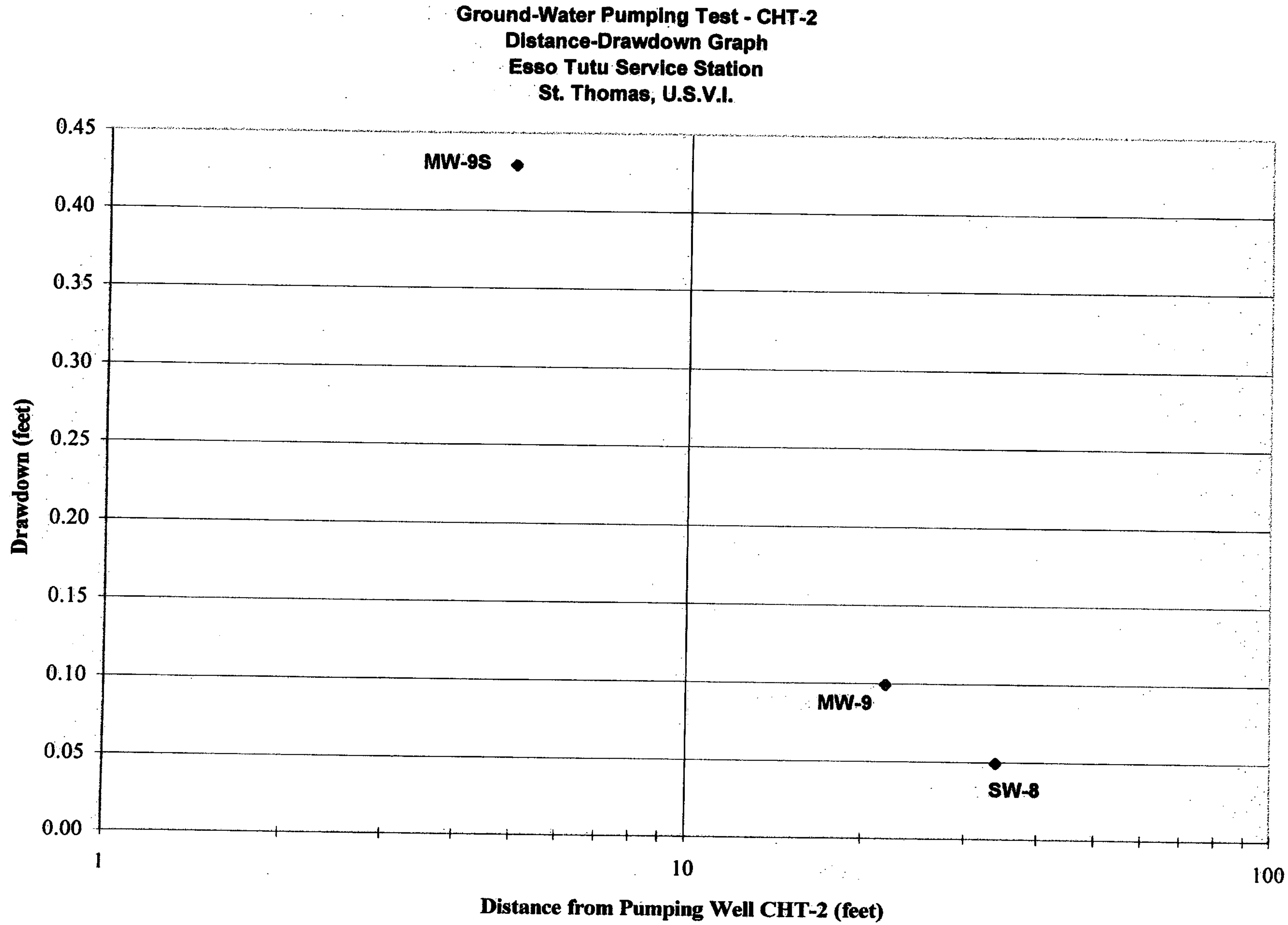
$$X_L = \frac{48}{(2)*(3.14)*(0.144)*(80)*(0.04)} = 17 \text{ feet}$$

@ 0.50 gpm $$Y_L = \pm \frac{96}{(2)*(0.144)*(80)*(0.04)} = \pm 104 \text{ feet} \qquad Y_L = 208 \text{ feet}$$

$$X_L = \frac{96}{(2)*(3.14)*(0.144)*(80)*(0.04)} = 33 \text{ feet}$$

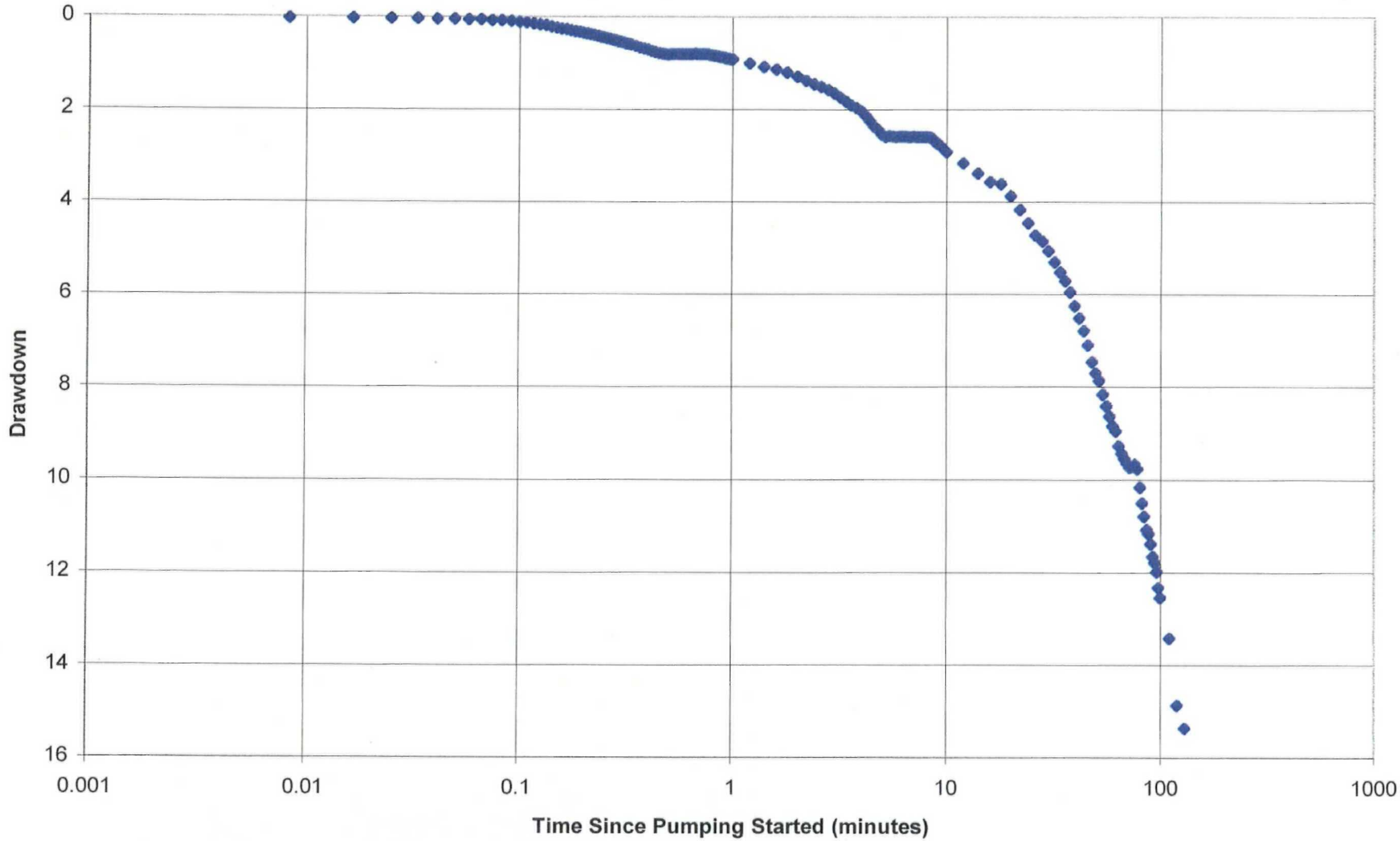
@ 1.0 gpm $$Y_L = \pm \frac{192}{(2)*(0.144)*(80)*(0.04)} = \pm 208 \text{ feet} \qquad Y_L = 416 \text{ feet}$$

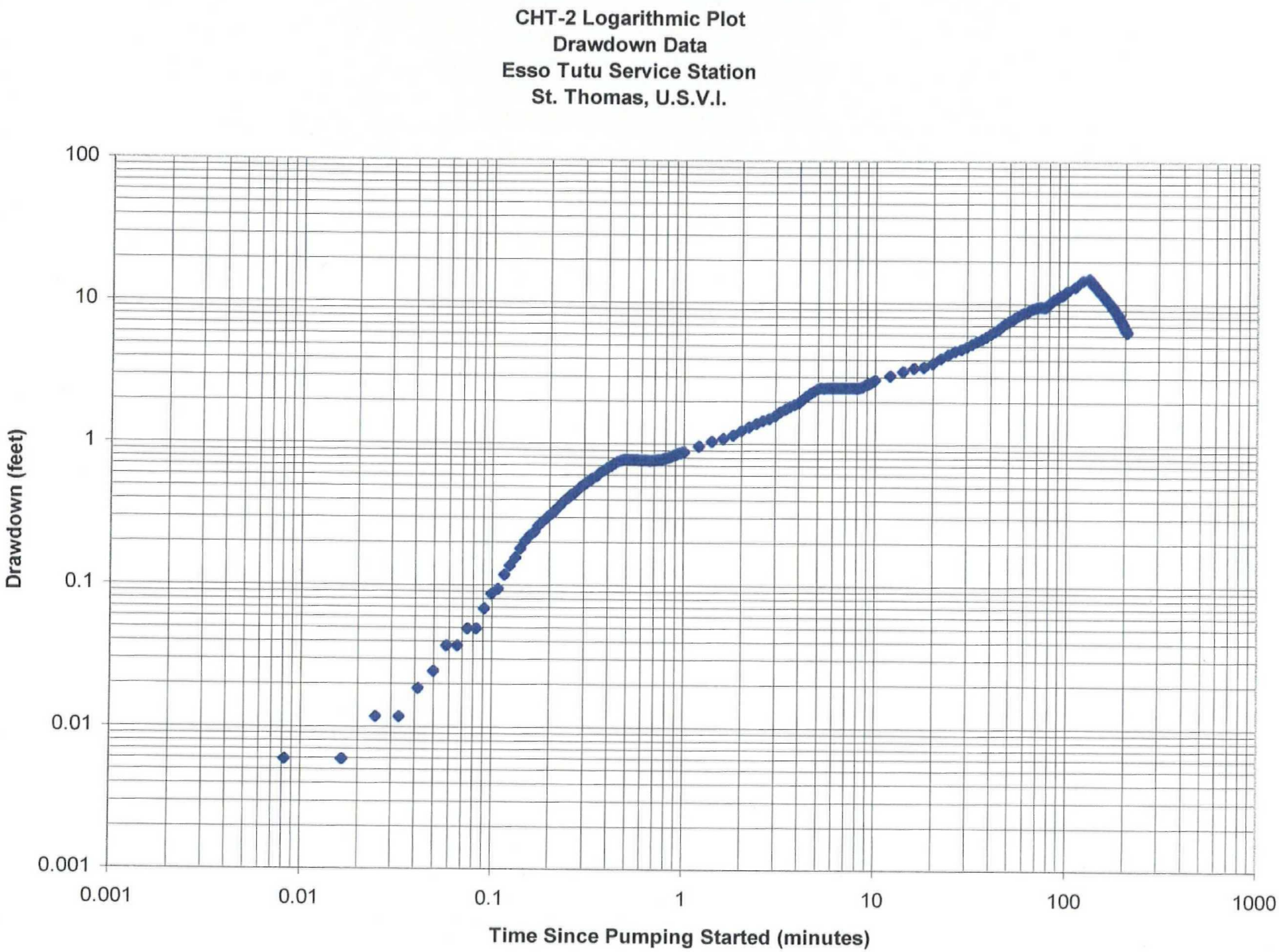
$$X_L = \frac{192}{(2)*(3.14)*(0.144)*(80)*(0.04)} = 66 \text{ feet}$$



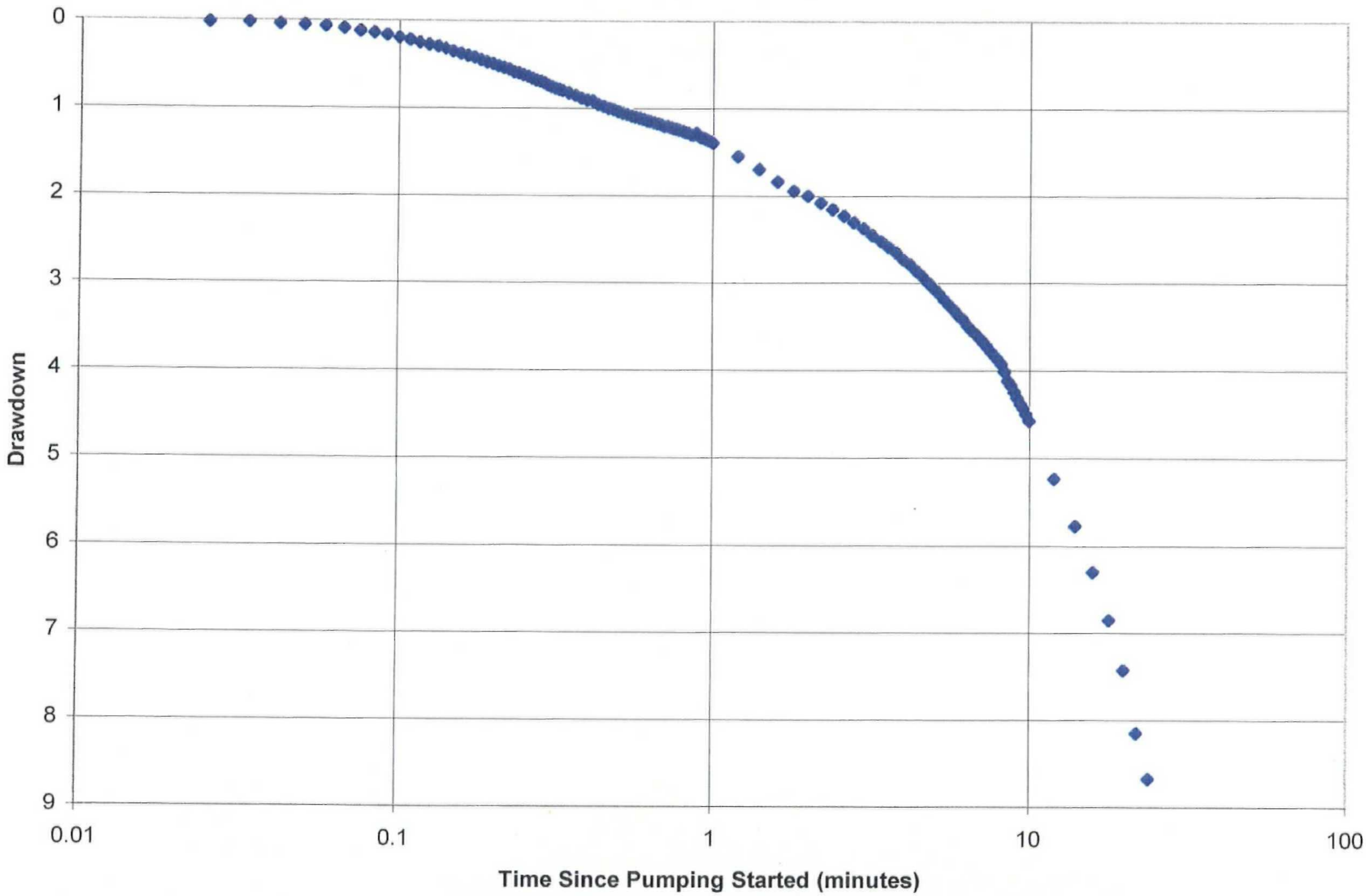
Ground-Water Pumping Test - CHT-2
Distance-Drawdown Graph
Esso Tutu Service Station
St. Thomas, U.S.V.I.
MW-9S
MW-9
SW-8
Drawdown (feet)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1
10
100
Distance from Pumping Well CHT-2 (feet)

CHT-2 Semi-Logarithmic Plot
Drawdown Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.

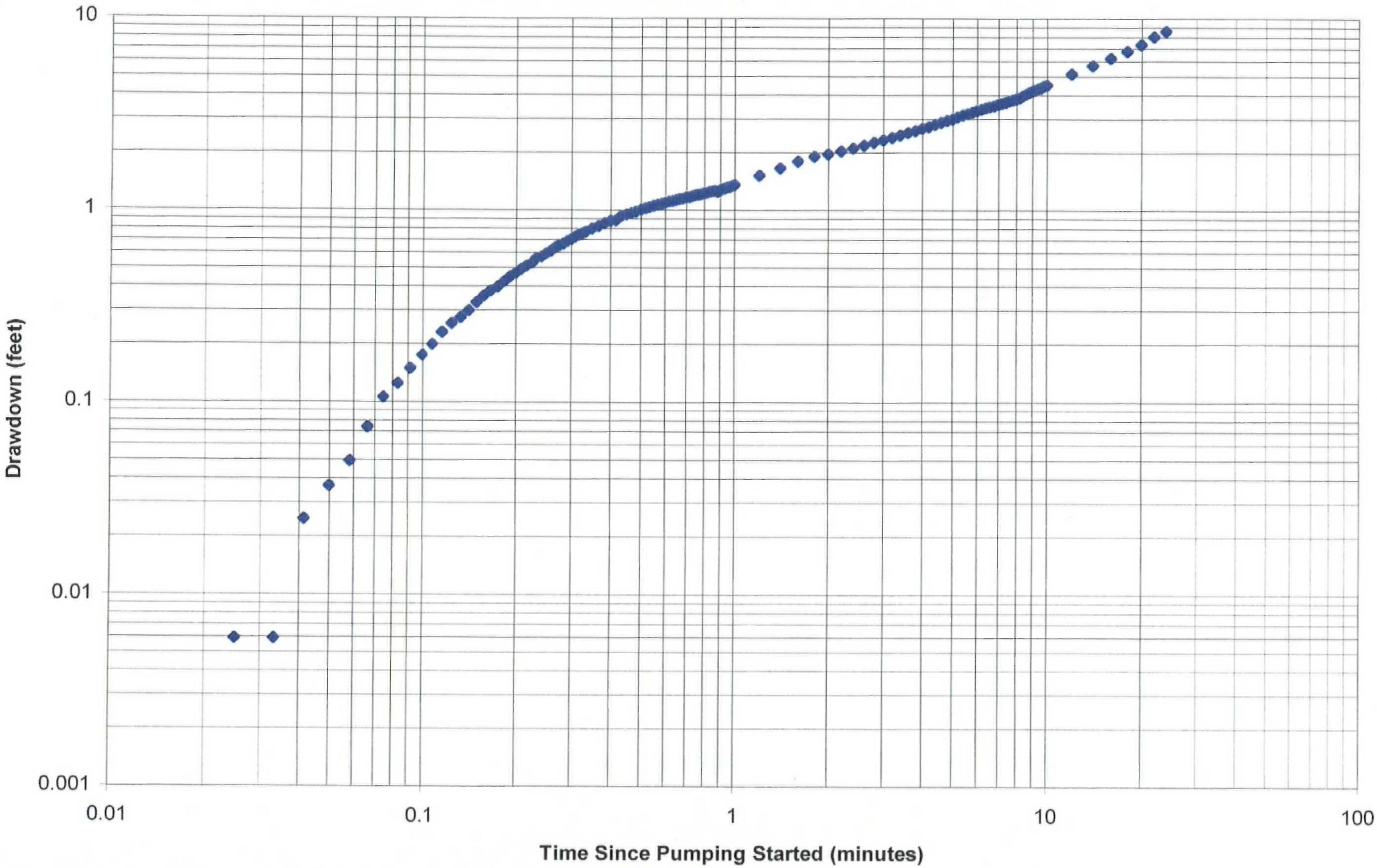



CHT-2 Logarithmic Plot
Drawdown Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.
100
10
1
0.1
0.01
0.001
Drawdown (feet)
0.001
0.01
0.1
1
10
100
1000
Time Since Pumping Started (minutes)

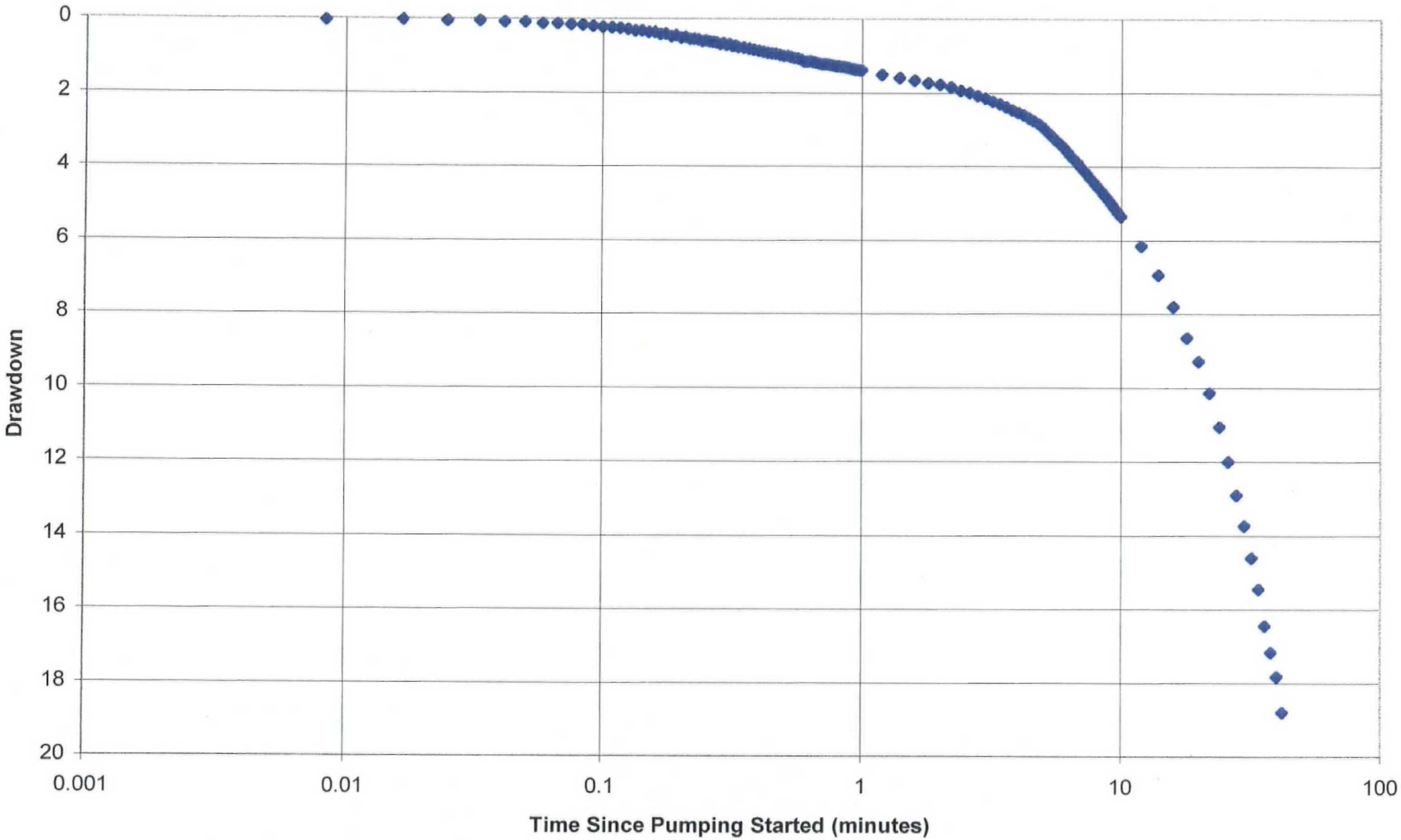
SW-1 Semi-Logarithmic Plot
Drawdown Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.



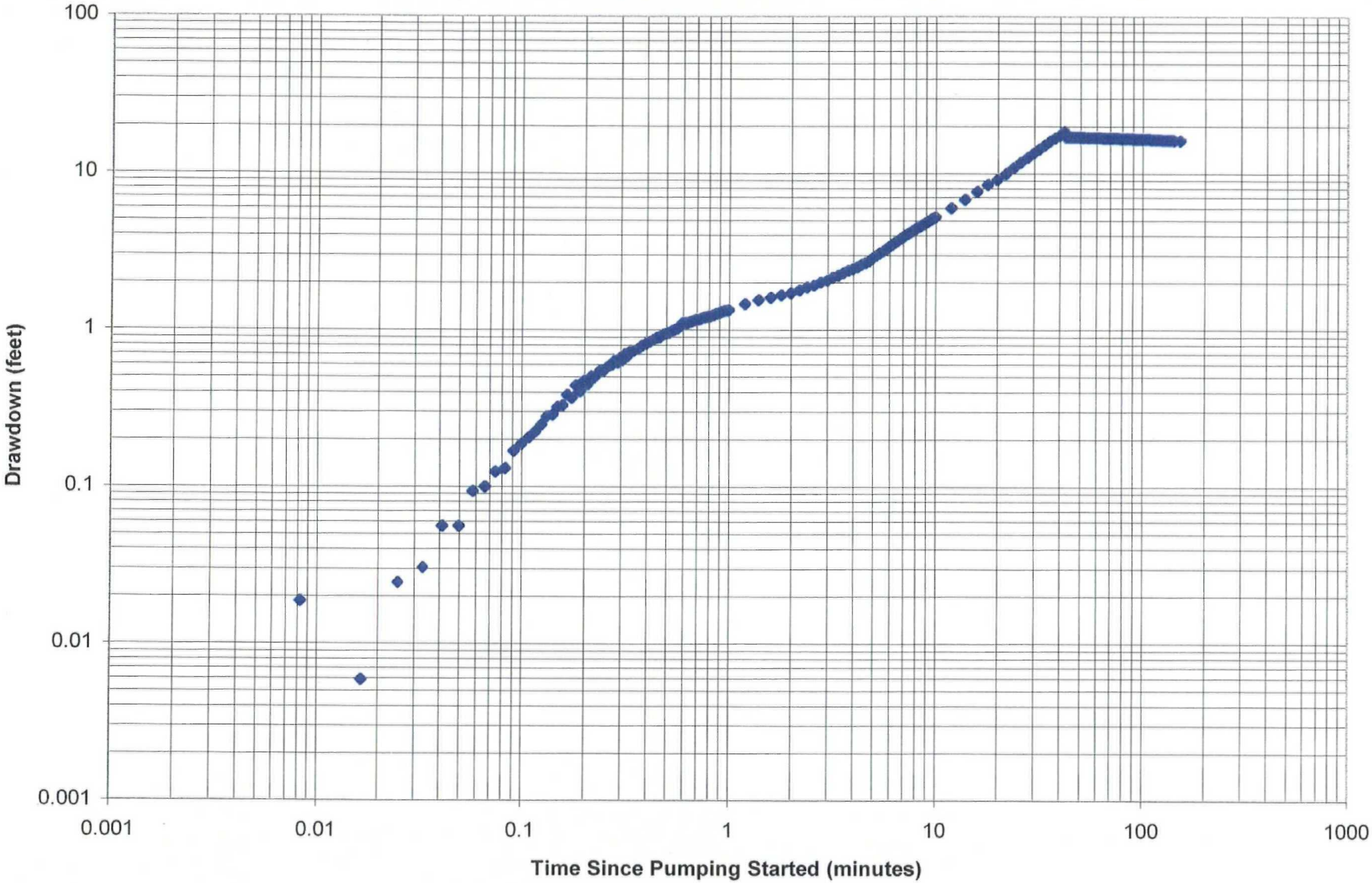
SW-1 Logarithmic Plot
Drawdown Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.



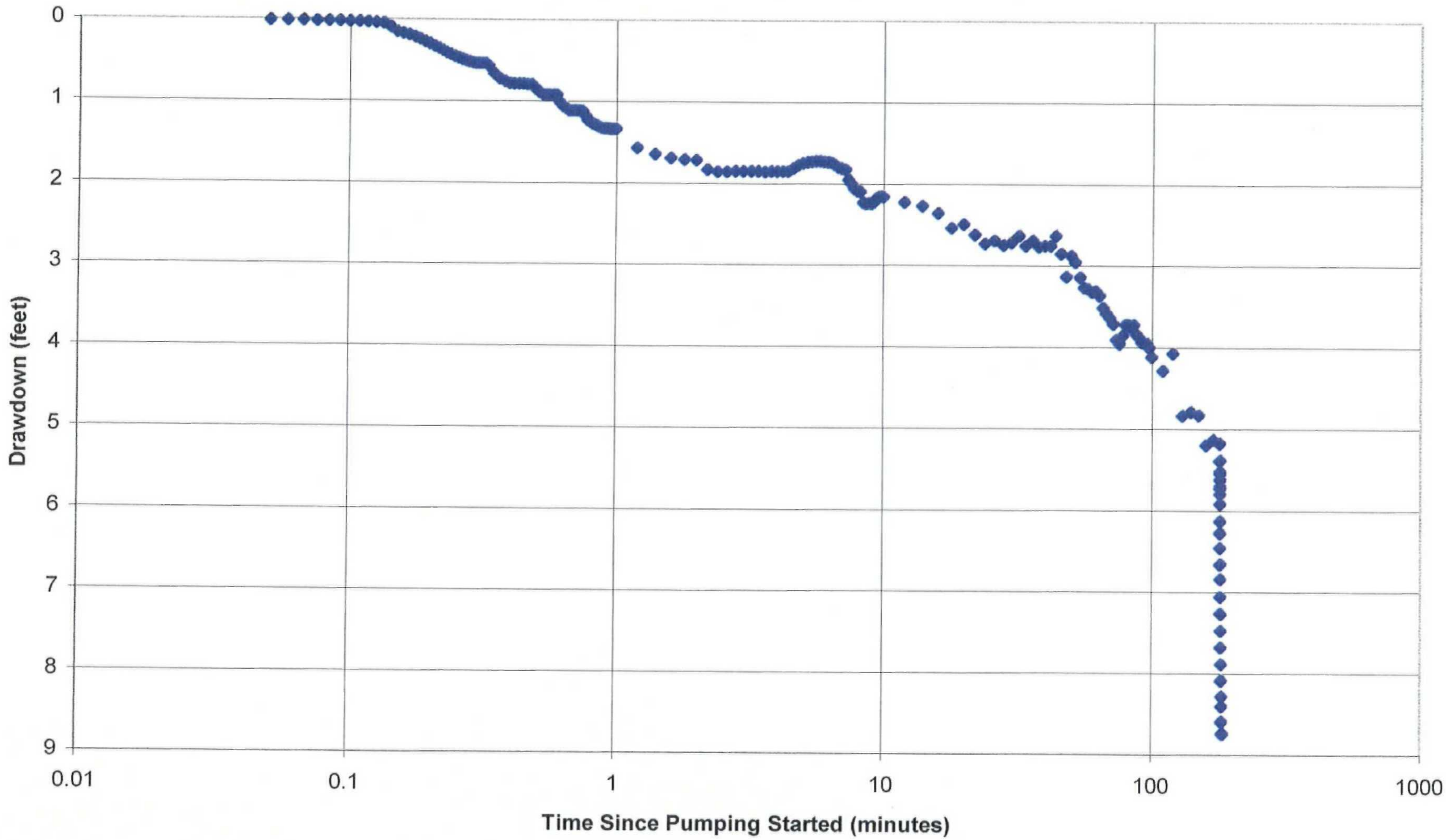
SW-3 Semi-Logarithmic Plot
Drawdown Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.



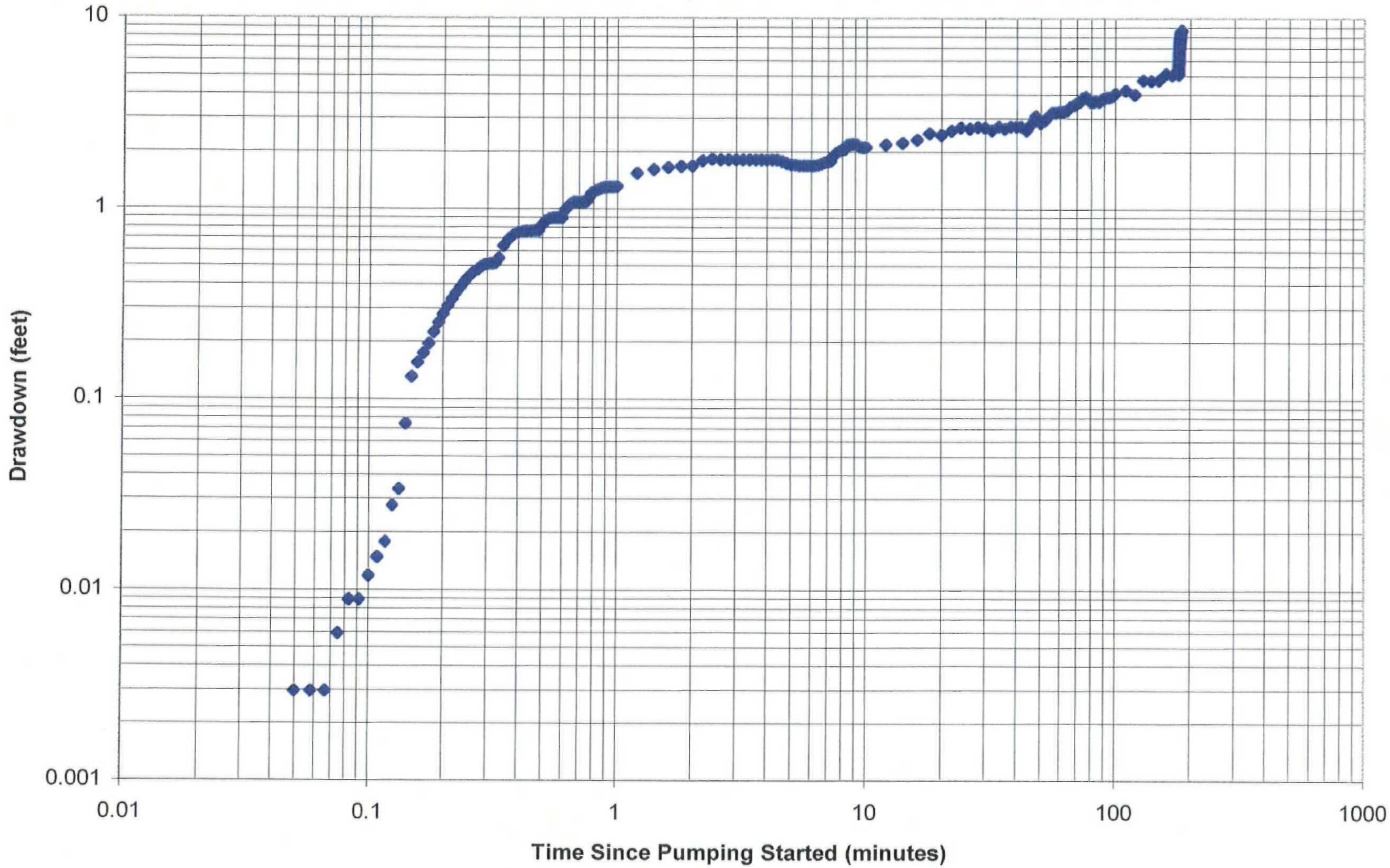
SW-3 Logarithmic Plot
Drawdown Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.



SW-7 Semi-Logarithmic Plot
Drawdown Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.



SW-7 Logarithmic Plot
Drawdown Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.



CLEANUP ESTIMATES - REMEDIAL WORK ELEMENT I
SOIL VAPOR EXTRACTION (SVE) SYSTEM

1. CONTAMINANT MASS

A. immediate vicinity of north oil/water separator

i avg. contaminant concentration = 4000 mg/kg TPH as gasoline
400 mg/kg TPH as diesel
4400 mg/kg

(avg. concentrations for SS-3, SS-4, SS-5, SS-7, SS-8; Table 2-1)

ii area of impact = 225 ft^2
(area of investigation plus five feet on all sides)

iii zone of impact = 9 feet
(3' to 12'; Table 2-1)

iv volume 2025 ft^3 (= ii*iii)

v amount = $4400 \frac{mg}{kg} * 2025\ ft^3 * 65 \frac{kg}{ft^3} * \frac{1\ pound}{454000\ mg}$

= 1276 pounds (avg. soil/rock density)

B. remainder of site - impact depth less than 10 feet

i avg. contaminant concentration = 65 mg/kg TPH as gasoline
125 mg/kg TPH as diesel
190 mg/kg

(avg. concentrations from all samples, 0.5 detection limit if ND; Table 2-2)

ii area of impact = 9100 ft^2
(area from Figure 3-2 less 225 ft^2 from step A)

iii zone of impact = 7 feet
(3' to 10'; Table 2-2)

iv volume 63700 ft^3 (= ii*iii)

v amount = $190 \frac{mg}{kg} * 63700\ ft^3 * 65 \frac{kg}{ft^3} * \frac{1\ pound}{454000\ mg}$

= 1733 pounds (avg. soil/rock density)

C. remainder of site - impact depth greater than 10 feet

i avg. contaminant concentration = 8065 mg/kg TPH as gasoline
1650 mg/kg TPH as diesel
9715 mg/kg

(avg. concentrations from all samples, 0.5 detection limit if ND; Table 2-2)

ii area of impact = 9300 ft^2
(area from Figure 3-2)

iii zone of impact = 2 feet
(10' to 12'; deeper impact within ground-water)

iv volume = 18600 ft^3 (= ii*iii)

v amount of contamination $= 9715 \frac{mg}{kg} * 18600\ ft^3 * 65 \frac{kg}{ft^3} * \frac{1\ pound}{454000\ mg}$ (avg. soil/rock density)

= 25871 pounds

vi assume that Remedial Work Element I (SVE) will address 1/2 of total amount and Remedial Work Element II (PSH, ground-water extraction program) will address 1/2 of total amount

D. total contaminant mass for to be treated by SVE system

=	1276	step A
	1733	step B
	12936	1/2 step C
	15944	pounds

2. CLEANUP TIME

A. Most of the mass contribution is from the capillary zone near the north oil/water separator. Since this is a high concentration zone, initial SVE removal rates are also likely to be high. After the bulk of the contamination is removed, residual soil concentrations will slowly decrease and reach an asymptotic limit. The following cleanup estimate is for SVE system operation only; residual contamination removal will be occur during bioventing activities.

B. avg. removal rate (Table 4-3b) $= 14 \frac{pounds}{day}$

C. cleanup time (until bioventing only) $= \frac{15944\ pounds}{14\ pounds/day} = 1107\ days =$ 36 months

3.0 years

CLEANUP ESTIMATES - REMEDIAL WORK ELEMENT II
GROUND-WATER EXTRACTION SYSTEM

1. CONTAMINANT MASS

A. dissolved VOCs

i avg. g-w contaminant concentration = 25 mg/L
(avg. concentrations from Table 4-7)

ii area of impact = 13100 ft^2
(see Figure 3-3)

iii zone of impact = 10 feet
(majority of dissolved contamination)

iv volume 131000 ft^3 (= ii*iii)

v porosity = 0.25

vi amount $= 25 \frac{mg}{kg} * 131000\ ft^3 * 0.25 * \frac{28.32\ L}{ft^3} \frac{1\ pound}{454000\ mg}$

= 51 pounds

B. contamination in capillary zone to be removed by Remedial Work Element II

i amount = 14651 pounds
(see SVE calculations)

C. total dissolved contaminant mass for removal by the Ground-Water extraction system

= 51	step A
14651	step B
14702	pounds

D. amount of contamination present as phase-separated hydrocarbons (PSH)

i volume = 460 gallons
(see Section 4.2.3)

ii amount = 3128 pounds
(6.8 pounds per gallon - PSH)

Assume that this amount of capillary zone contamination will be removed as PSH.

2. CLEANUP TIME

A. Ground-water cleanup of petroleum hydrocarbon contamination typically requires approximately seven volume "flushes" of water.

i flush volume $= 60 \underset{\text{(aquifer thickness)}}{} * \underset{\text{(capture area)}}{30000\ ft^2} * 0.25 * \frac{7.48 \text{ gallons}}{ft^3} * \underset{\text{(volumes)}}{7}$

= 23562000 gallons

ii time to process $= \frac{23562000 \text{ gallons day}}{6 \text{ gpm} * 1440 \text{ min}}$ = 2727 days = 90 months = 7.5 years

B. avg. removal rate (Table 4-7) $= 0.08 \frac{\text{pounds}}{\text{hour}}$

C. amount removed (via ground-water extraction) $= 0.08 \frac{\text{pounds}}{\text{hour}} *$ 2727 days = 5236 pounds

D. total dissolved/PSH/residual contaminant mass	14702
amount removed via g-w extraction	-5236
amount removed as PSH	-3128
amount to be removed via SVE & bioventing	6338 pounds

Process Flow Chart and Equipment Information

REMEDIAL SYSTEM DESIGN
PROCESS FLOW CHART
(please refer to drawing sheet T-2)

STREAM NO.	1	2	3	4	5	6	7	8	9	10
DESCRIPTION	WATER	PSH	WATER	WATER	WATER	WATER	WATER	WATER	WATER	AIR
Temperature (°F)	80	80	80	80	80	80	80	80	80	80
pH	7.0	NA	7.0-8.0	7.0-8.0	7.0-8.0	7.0-8.3	7.0-8.3	7.0-8.3	5	
Flow Rate (gpm, scfm)	15	15	15	15	15	15	15	15	< 0.01	300
Benzene (µg/L, ppmv)	2250	NA	2250	2250	2250	< 1	< 1	< 1	0	0
Toluene (µg/L, ppmv)	150	NA	150	150	150	< 1	< 1	< 1	0	0
Ethylbenzene (µg/L, ppmv)	700	NA	700	700	700	< 1	< 1	< 1	0	0
Xylenes (µg/L, ppmv)	1900	NA	1900	1900	1900	< 1	< 1	< 1	0	0
MTBE (µg/L, ppmv)	20000	NA	20000	20000	20000	384	384	384	0	0
Total VOCs (ppmv)										0
TSS (mg/L)	400	NA	400	400	<40	<40	<40	<40	0	

STREAM NO.	11	12	13	14	15	16	17	18	19	20	21
DESCRIPTION	AIR	AIR	AIR	AIR	AIR	AIR	PSH	WATER	AIR	AIR	AIR
Temperature (°F)	80	80	80	80	220	1500	80	80	80	120	80
pH							NA	7.0			
Flow Rate (gpm, scfm)	240	125	185	185	250	250	< 1	< 1	25	25	60
Benzene (µg/L, ppmv)	5.5	5.5	5.3	5.3	3.9	0.20	NA	NA	5.5	0	4.9
Toluene (µg/L, ppmv)	0.9	0.9	0.7	0.7	0.5	0.02	NA	NA	0.9	0	0.2
Ethylbenzene (µg/L, ppmv)	12	12	8.5	8.5	6.3	0.31	NA	NA	12	0	1.1
Xylenes (µg/L, ppmv)	1.4	1.4	1.9	1.9	1.4	0.07	NA	NA	1.4	0	3.0
MTBE (µg/L, ppmv)	<1	<1	13.2	13.2	0.7	0.04	NA	NA	<1	0	38.6
Total VOCs (ppmv)	375	375	269	269	199	10.0	NA	NA	375	0	48
TSS (mg/L)							NA	<40			

MTBE = methyl tertiary butyl ether, VOCs = volatile organic compounds, TSS = total suspended solids; PSH = phase-separated hydrocarbons

gpm = gallons per minute; scfm = standard cubic feet per minute, mg/L = micrograms per liter; mg/L = milligrams per liter; ppmv = parts per million by volume

NA = not available, but will not affect system performance; shaded areas = not applicable

The system maximum peak flow of 15 gpm was used for all calculations to provide a "worst-case" scenario.

The maximum VOC concentration of 375 ppmv was used for all calculations to provide a "worst-case" scenario.

NEEP™ Systems
environmental technologies

North East Environmental Products, Inc.
17 Technology Drive West Lebanon, NH 03784
603-298-7061 Fax: 603-298-7063

Date: Friday, May 29, 1998

To: Paul Fisher / Lavine-Frike
Fax: 908 526-7886
Phone: 908 526-1000 x 416

CC:
Fax:
Phone:

From: Bob Clarke / NEEP
No Pages: 2 (including this cover page)
RE:
Notes:

The Modeling software operation is based on actual test data we performed on the ShallowTray strippers. Modeler uses equations and the curve fitted test data to predict removal efficiencies.

Enclosed is an article that states this. It was the only statement I could find.

Bob Clarke
Project Manager
Senior Mechanical Engineer

fax 59 Lavine

incorporated into computer models that can be used to select air stripping equipment according to the environmental engineer's performance criteria and variables such as the chemical to be removed, air flow rates, water flow rate, water temperature, and others.

The modeling of air stripping systems is extremely important to the environmental engineer for several reasons:

1. A precise understanding of how variously configured air stripping systems will perform under a wide variety of conditions makes it possible for the manufacturer to assume liability for the performance of properly installed systems. This relieves the consulting engineer of the burden of performing his or her own performance testing.
2. The computer model makes it possible to perform hours worth of manual calculations in a matter of minutes. As a result, a manufacturer can respond quickly to a request for quotes or changes in performance criteria. Such responsiveness cannot be overemphasized. While site owners are given years to perform initial assessments and feasibility studies, they are typically given only 90 days to complete the final design and engineering of a treatment system. This causes enormous time pressures.
3. Modeling makes it possible to quickly troubleshoot performance issues with installed systems. These are frequently due to changes in site conditions (e.g., flow rates or contaminant concentrations). Based on the modeled data, it is possible to recommend modifications to system operation or configuration to improve performance.

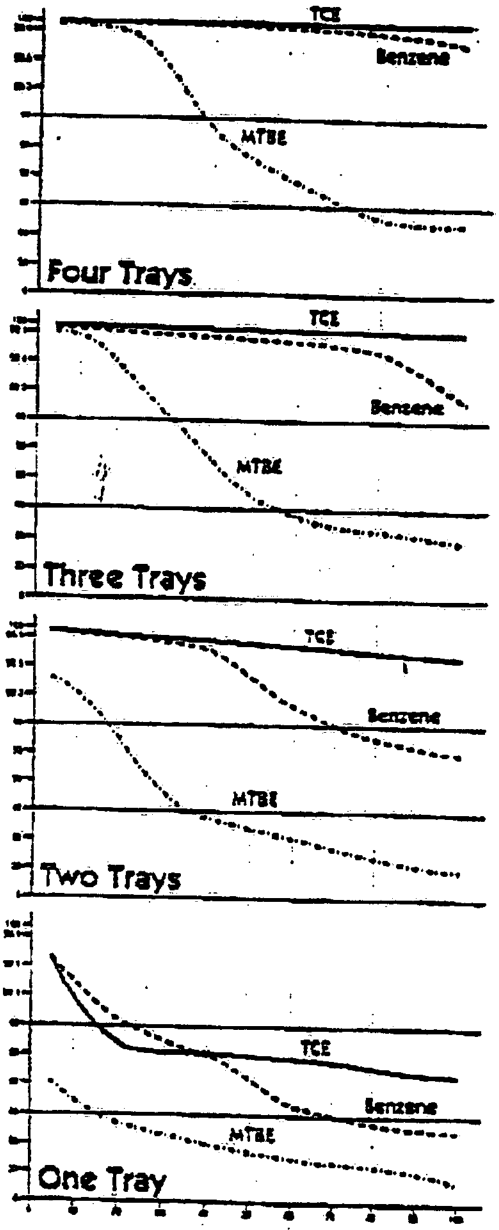


Figure 3

The degree of confidence one can have in modeled data for air stripper selection is limited by the manufacturer's experience with the compound matrix (i.e., the water itself, the primary contaminant(s), and other chemicals and minerals that may be present.) Computer models for selecting air strippers can be based on theoretical equations or on empirical data. However, the best models rely on theoretical equations calibrated to actual test data. This gives the engineer maximum assurance that predicted performance will closely approximate performance in the field. Some manufacturers perform many such tests every week, just to extend the data available on their systems and to keep pace with continually more demanding performance criteria. The value of the air stripper depends to a great extent on the scope and precision of its modeling.

Treatment Efficiencies

The higher the concentration of contamination in the water, the more air will be needed to volatilize and carry it away. To improve the treatment efficiency, it is therefore necessary to increase the air-water ratio. Tray-type, low-profile strippers have inherently high air-water ratios because relatively large volumes of air are required to transform water in the tray into a froth. Without oversizing the blowers, such units are capable of removing such highly soluble contaminants as methyl(tert)butyl ether (MTBE), methylene chloride, and acetone.

If additional treatment efficiency is required, it is possible to further increase the air-water ratio by reducing the flow rate of water through the system. Tray-type units may be operated anywhere within their rated water flow range. A small system may have a flow rating of 1 to 15 gallons per minute (gpm), while a large unit may have a range of 16 to 360 gpm. Either system may be operated at the lower limit to obtain a high contaminant removal efficiency. Residence time in a tower may also be a factor for improving treatment efficiency, but this generally involves increasing the height of the tower. Packed towers should not be operated at low flow rates because adequate mass transfer surface area cannot be generated.

Residence time in tray-type systems can be improved by adding more trays. In a multi-tray system, when water has reached the end of one tray, it falls into the next for additional treatment. Adding trays also makes it possible to operate at higher water flow rates without sacrificing air stripping efficiency. Figure 3 shows removal efficiency vs. flow rates for systems with one, two, three, and four trays, respectively. The ability to easily remove or add trays in the field makes it possible to periodically tune the system for improved performance or reduced operating costs.

ShallowTray
low profile air strippers

DRAFT

System Performance Estimate

Client and Proposal Information:

Forensic Environmental

Model Chosen:	2300
Water Flow Rate:	10.0 gpm
Air Flow Rate:	300 cfm
Water Temp:	60.0 F
Air Temp:	60.0 F
A/W Ratio:	224.4
Safety Factor:	None

Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Benzene	2250 ppb 15 ppb	30 ppb 0.011105 98.6701%	1 ppb 0.011250 99.9823%	<1 ppb 0.011255 99.9998%	<1 ppb 0.011255 100.0000%
MTBE	20000 ppb 1000 ppb	4364 ppb 0.078214 78.1819%	953 ppb 0.095277 95.2397%	208 ppb 0.099004 98.9614%	46 ppb 0.099814 99.7734%
p-Xylene	1900 ppb 50 ppb	25 ppb 0.009379 98.7294%	1 ppb 0.009499 99.9839%	<1 ppb 0.009504 99.9998%	<1 ppb 0.009504 100.0000%
Toluene	150 ppb 50 ppb	3 ppb 0.000735 98.3680%	<1 ppb 0.000750 99.9734%	<1 ppb 0.000750 99.9996%	<1 ppb 0.000750 100.0000%
Ethyl Benzene	700 ppb 50 ppb	8 ppb 0.003462 98.8798%	<1 ppb 0.003501 99.9874%	<1 ppb 0.003502 99.9999%	<1 ppb 0.003502 100.0000%
Trichloroethylene	5 ppb 1 ppb	<1 ppb 0.000025 99.7067%	<1 ppb 0.000025 99.9991%	<1 ppb 0.000025 100.0000%	<1 ppb 0.000025 100.0000%
Tetrachloroethylene	15 ppb 1 ppb	<1 ppb 0.000075 99.8327%	<1 ppb 0.000075 99.9997%	<1 ppb 0.000075 100.0000%	<1 ppb 0.000075 100.0000%
1,1-Dichloroethylene	25 ppb 1 ppb	<1 ppb 0.000124 99.4946%	<1 ppb 0.000125 99.9974%	<1 ppb 0.000125 100.0000%	<1 ppb 0.000125 100.0000%
Vinyl Chloride	5 ppb 1 ppb	<1 ppb 0.000025 99.9822%	<1 ppb 0.000025 100.0000%	<1 ppb 0.000025 100.0000%	<1 ppb 0.000025 100.0000%

DRAFT

Contaminant	Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Acetone	5 ppb 1 ppb	4 ppb 0.000005 20.8477%	4 ppb 0.000005 37.3491%	3 ppb 0.000010 50.4104%	2 ppb 0.000015 60.7487%
Due to its miscibility with water, acetone removal is difficult to predict. Call your neep representative for more in					
Methylene Chloride	15 ppb 1 ppb	1 ppb 0.000070 98.0893%	<1 ppb 0.000075 99.9635%	<1 ppb 0.000075 99.9993%	<1 ppb 0.000075 100.0000%

This report has been generated by ShallowTray Modeler software version 2.1W. This software is designed to assist a skilled operator in predicting the performance of a ShallowTray air stripping system. North East Environmental Products, Inc. is not responsible for incidental or consequential damages resulting from the improper operation of either the software or the air stripping equipment.
Report generated: 9/16/1998

ShallowTray low profile air strippers

DRAFT

System Performance Estimate

Client and Proposal Information:

Forensic Environmental

Model Chosen:	2300
Water Flow Rate:	12.0 gpm
Air Flow Rate:	300 cfm
Water Temp:	60.0 F
Air Temp:	60.0 F
A/W Ratio:	187.0
Safety Factor:	None

Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Benzene	2250 ppb 15 ppb	50 ppb 0.013206 97.7943%	2 ppb 0.013494 99.9513%	<1 ppb 0.013506 99.9989%	<1 ppb 0.013506 100.0000%
MTBE	20000 ppb 1000 ppb	5607 ppb 0.086396 71.9692%	1572 ppb 0.110617 92.1428%	441 ppb 0.117406 97.7976%	124 ppb 0.119309 99.3826%
p-Xylene	1900 ppb 50 ppb	41 ppb 0.011159 97.8813%	1 ppb 0.011399 99.9551%	<1 ppb 0.011405 99.9990%	<1 ppb 0.011405 100.0000%
Toluene	150 ppb 50 ppb	4 ppb 0.000876 97.3574%	<1 ppb 0.000900 99.9302%	<1 ppb 0.000900 99.9982%	<1 ppb 0.000900 100.0000%
Ethyl Benzene	700 ppb 50 ppb	14 ppb 0.004118 98.1044%	1 ppb 0.004196 99.9641%	<1 ppb 0.004202 99.9993%	<1 ppb 0.004202 100.0000%
Trichloroethylene	5 ppb 1 ppb	<1 ppb 0.000030 99.5170%	<1 ppb 0.000030 99.9977%	<1 ppb 0.000030 100.0000%	<1 ppb 0.000030 100.0000%
Tetrachloroethylene	15 ppb 1 ppb	<1 ppb 0.000090 99.7110%	<1 ppb 0.000090 99.9992%	<1 ppb 0.000090 100.0000%	<1 ppb 0.000090 100.0000%
1,1-Dichloroethylene	25 ppb 1 ppb	<1 ppb 0.000149 99.3448%	<1 ppb 0.000150 99.9957%	<1 ppb 0.000150 100.0000%	<1 ppb 0.000150 100.0000%
Vinyl Chloride	5 ppb 1 ppb	<1 ppb 0.000030 98.9627%	<1 ppb 0.000030 100.0000%	<1 ppb 0.000030 100.0000%	<1 ppb 0.000030 100.0000%

DRAFT

Contaminant	Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Acetone	5 ppb 1 ppb	5 ppb <.000001 16.6703%	4 ppb 0.000006 30.5616%	3 ppb 0.000012 42.1372%	3 ppb 0.000012 51.7631%
Methylene Chloride	15 ppb 1 ppb	1 ppb 0.000084 96.6073%	<1 ppb 0.000090 99.8849%	<1 ppb 0.000090 99.9961%	<1 ppb 0.000090 99.9999%

Due to its miscibility with water, acetone removal is difficult to predict. Call your neep representative for more in

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ShallowTray
low profile air strippers

DRAFT

System Performance Estimate

Client and Proposal Information:

Forensic Environmental

Model Chosen:	2300
Water Flow Rate:	15.0 gpm
Air Flow Rate:	300 cfm
Water Temp:	60.0 F
Air Temp:	60.0 F
A/W Ratio:	149.6
Safety Factor:	None

Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Benzene	2250 ppb 15 ppb	93 ppb 0.016185 95.8802%	4 ppb 0.016852 99.8303%	<1 ppb 0.016881 99.9930%	<1 ppb 0.016882 99.9997%
MTBE	20000 ppb 1000 ppb	7441 ppb 0.094234 62.7985%	2768 ppb 0.129297 86.1605%	1030 ppb 0.142338 94.8515%	384 ppb 0.147185 98.0847%
p-Xylene	1900 ppb 50 ppb	76 ppb 0.013686 96.0165%	4 ppb 0.014226 99.8413%	<1 ppb 0.014255 99.9937%	<1 ppb 0.014256 99.9997%
Toluene	150 ppb 50 ppb	8 ppb 0.001065 95.2081%	1 ppb 0.001118 99.7704%	<1 ppb 0.001125 99.9890%	<1 ppb 0.001125 99.9995%
Ethyl Benzene	700 ppb 50 ppb	26 ppb 0.005067 96.3704%	1 ppb 0.005245 99.8683%	<1 ppb 0.005252 99.9952%	<1 ppb 0.005252 99.9998%
Trichloroethylene	5 ppb 1 ppb	<1 ppb 0.000037 99.0458%	<1 ppb 0.000038 99.9909%	<1 ppb 0.000038 99.9999%	<1 ppb 0.000038 100.0000%
Tetrachloroethylene	15 ppb 1 ppb	<1 ppb 0.000112 99.3903%	<1 ppb 0.000113 99.9963%	<1 ppb 0.000113 100.0000%	<1 ppb 0.000113 100.0000%
1,1-Dichloroethylene	25 ppb 1 ppb	<1 ppb 0.000186 99.0827%	<1 ppb 0.000188 99.9916%	<1 ppb 0.000188 99.9999%	<1 ppb 0.000188 100.0000%
Vinyl Chloride	5 ppb 1 ppb	<1 ppb 0.000037 99.8978%	<1 ppb 0.000038 99.9999%	<1 ppb 0.000038 100.0000%	<1 ppb 0.000038 100.0000%

DRAFT

Contaminant	Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Acetone	5 ppb 1 ppb	5 ppb <.000001 12.8636%	4 ppb 0.000008 24.0725%	4 ppb 0.000008 33.8395%	3 ppb 0.000015 42.3502%
Methylene Chloride	15 ppb 1 ppb	2 ppb 0.000098 92.7069%	<1 ppb 0.000112 99.4681%	<1 ppb 0.000113 99.9612%	<1 ppb 0.000113 99.9972%

Due to its miscibility with water, acetone removal is difficult to predict. Call your neep representative for more in

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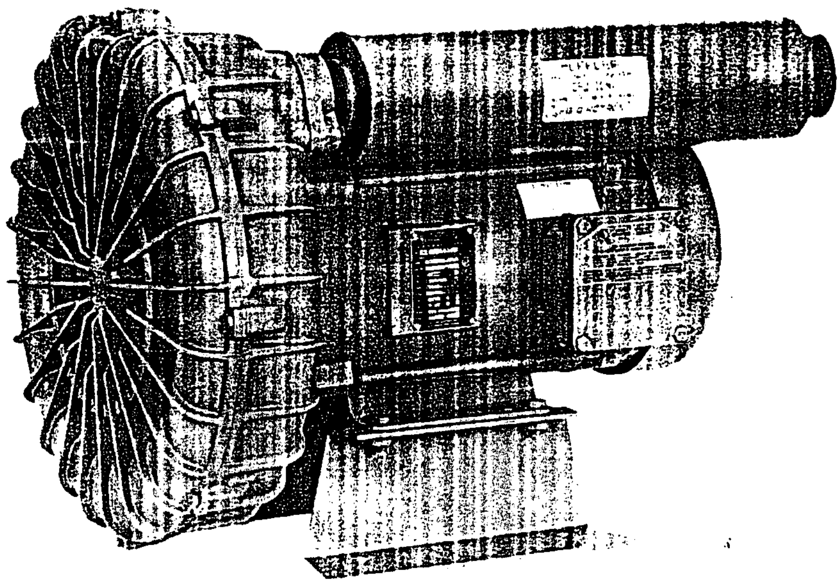
Report generated: 9/16/1998

EN 6
Explosion-Proof Regenerative Blower

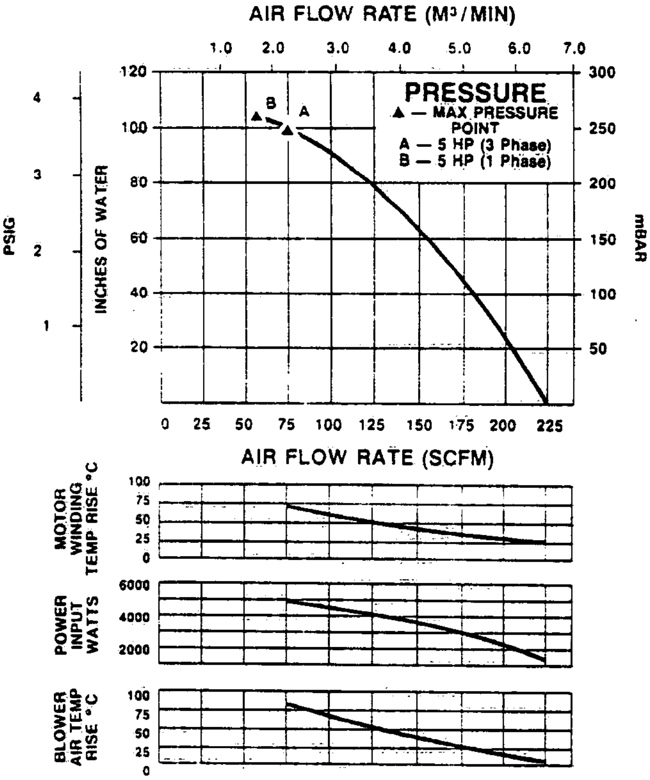
FEATURES
- Manufactured in the USA
- Maximum flow: 225 SCFM
- Maximum pressure: 104″ WG
- Maximum vacuum: 85″ WG
- Standard motor: 5.0 HP
- Blower construction — cast aluminum housing, cover, impeller & manifold; cast iron flanges
- UL & CSA approved motors for Class I, Group D atmospheres
- Sealed blower assembly
- Quiet operation within OSHA standards

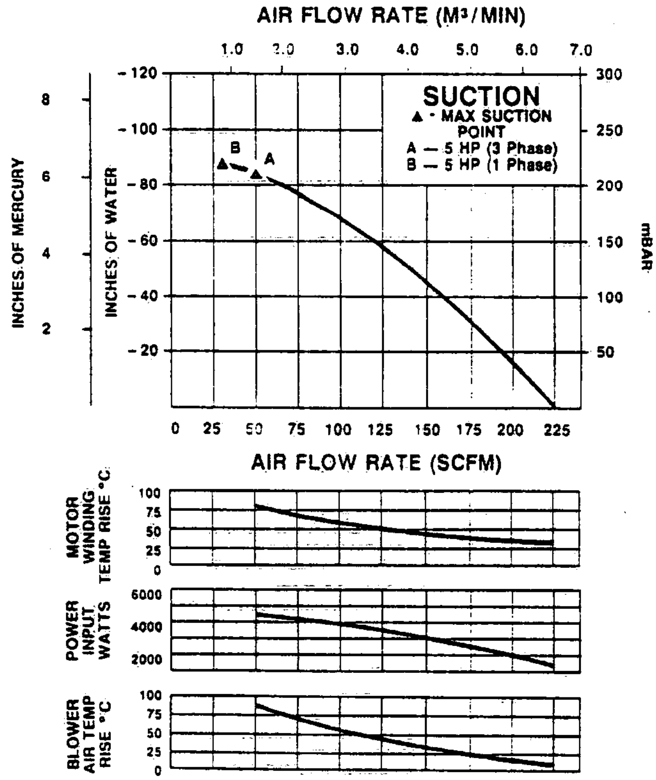
OPTIONS
- TEFC motors
- 50 Hz motors
- International voltages
- Other HP motors
- Corrosion resistant surface treatments
- Remote drive (motorless) models

ACCESSORIES
- Moisture separators
- Explosion-proof motor starters
- Inline & inlet filters
- Vacuum & pressure gauges
- Relief valves
- External mufflers



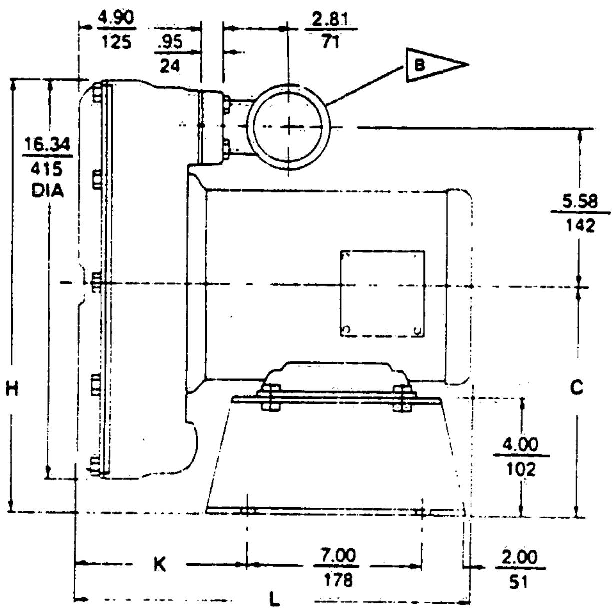
BLOWER PERFORMANCE AT STANDARD CONDITIONS

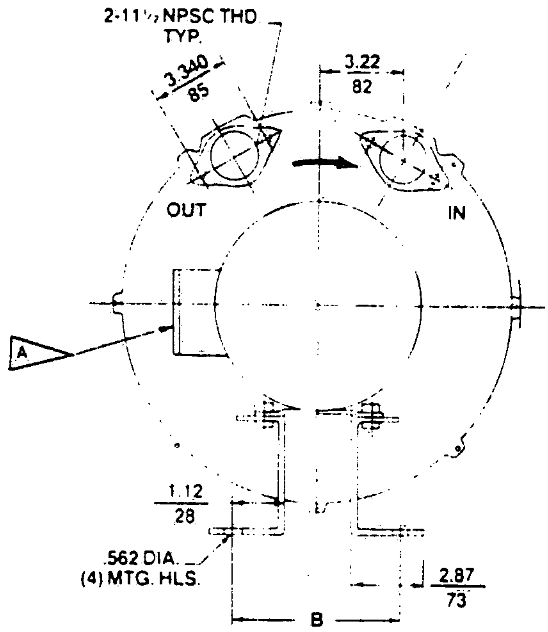




EG&G ROTRON, SAUGERTIES, N.Y. 12477 • 914/246-3401 • FAX 914/246-3802

EN 6
Explosion-Proof Regenerative Blower





MODEL	H (IN/MM)	K (IN/MM)	L (IN/MM)	C (IN/MM)	B (IN/MM)
EN6F72L	16.67/423	6.98/177	20.37/517	8.50/216	8.00/203
EN6F5L	17.43/443	8.36/212	21.06/535	9.25/235	9.00/229

DIMENSIONS: $\frac{IN}{MM}$
TOLERANCES: .XX ± $\frac{.12}{3}$
(UNLESS OTHERWISE NOTED)

A — 0.75" NPT CONDUIT CONNECTION AT 12 O'CLOCK POSITION

B — 90° ELBOW SUPPLIED ON 1 PHASE MODEL ONLY

SPECIFICATIONS

MODEL	EN6F5L	EN6F72L		EN6F86L
Part No.	038361	038180		038438
Motor Enclosure Type	Explosion-proof	Explosion-proof		Explosion-proof
Horsepower	5.0	5.0		5.0
Phase — Frequency	Single - 60 Hz	Three - 60 Hz		Three - 60 Hz
Voltage [1]	230	230	460	575
Motor Nameplate Amps	19.5	14	7	5.6
Maximum Blower Amps [3]	22.8	15.8	7.9	6.3
Inrush Amps	118	96	48	38
Starter Size	2	1	0	0
Service Factor	1.0	1.0		1.0
Thermal Protection [2]	Pilot Duty	Pilot Duty		Pilot Duty
Bearing Type	Sealed, Ball	Sealed, Ball		Sealed, Ball
Shipping Weight	232 lb (105 kg)	160 lb (73 kg)		160 lb (73 kg)

BLOWER LIMITATIONS

Min. Flow @ Max. Suction	30 SCFM @ −85" WG	50 SCFM @ −85" WG	50 SCFM @ −85" WG
Min. Flow @ Max. Pressure	54 SCFM @ 104" WG	75 SCFM @ 100" WG	75 SCFM @ 100" WG

[1] All dual voltage 3 phase motors are factory tested and certified to operate on 200-230/400-460 VAC-3 ph-60 Hz. All dual voltage 1 phase motors are factory tested and certified to operate on 110-120/200-230 VAC-1 ph-60 Hz.
[2] Maximum operating temperatures: Motor winding temperature (winding rise plus ambient) should not exceed 140°C for Class F insulation or 120°C for Class B insulation. Blower outlet air temperature should not exceed 140°C (air temperature rise plus ambient).
[3] Corresponds to the performance point at which the blower and/or motor temperature rise reaches the limit of the thermal protection in the motor.

Specifications subject to change without notice. Please contact factory for specification updates.

APPENDIX B
Site-Related Permits

FACT SHEET TPDES PERMIT VI0040703
[modified 04-29-98]

received
4/29/98

1. **Facility Name, Location, and Type:**
Permittee: ESSO TUTU SERVICE STATION GROUNDWATER REMEDIATION
TPDES Permit Number: VI0040703
Location: #384 Estate Anna's Retreat, St. Thomas, U.S. Virgin Islands

OUTFALL NO. 001 TURPENTINE RUN
Latitude: 18° 20' 26" North
Longitude: 64° 53' 19" West

Receiving Waters: Mangrove Lagoon is designated as Class "B" waters.
Facility Type: Ground Water Remediation Treatment Plant
SIC Code: Not Available
Point Source Category: AIR STRIPPER WITH POSSIBLE VAPOR PHASE GAC

2. **Discharge Quantity, Type, and Treatment:**

OUTFALL	DISCHARGE TYPE	FLOW	TREATMENT
001	TREATED GROUND WATER FROM EXISTING WELLS-SW-7, MW-9, & CHT-3.	14. 440 gpd.	AIR STRIPPER WITH CARBON ABSORPTION

TOTAL FLOW IS 14,440 gpd (0.014 MGD)

Post-it™ brand fax transmittal memo 7671 | # of pages ▸ 6
To Lehman | From Syedali
Co. | Co.
Dept. | Phone # 773 0565
Fax # 609 795 0574 | Fax #

Post-it™ brand fax transmittal memo 7671 | # of pages ▸ 6
To Maguire | From Syedali
Co. | Co.
Dept. | Phone # 773 0565
Fax # 610 594 3943 | Fax #

Effluent Limitations and Monitoring Requirements:

Parameter	Basis for Effluent Limits
Flow:	BPJ based on Permit Application Form 2C.
pH	Water Quality Based Limitation (WQL); T. 12, Virgin Islands rules and Regulations, Ch. 7, Section 186-3 (b) (2).
Total Organic Carbon	BPJ based on EPA approved New Jersey Pollutant Discharge Elimination System/Discharge to Surface Water (NJPDES/DSW) Permit No. NJ0102709 General Petroleum Product Clean-up Permit.
Total Suspended Solids	BPJ based on Permit NO. NJ0102709
Benzene	40 CFR 141 sections 141.61a (Federal MCLs)
Toulene	BPJ based on Permit NO. NJ0102709
Total Xylene	BPJ based on Permit NO. NJ0102709
Total BTEX	BPJ based on Permit NO. NJ0102709
Lead	BPJ based on Permit NO. NJ0102709
Petroleum Hydrocarbons	BPJ based on Permit NO. NJ0102709

3. **Public Comment:**
See Original TPDES Permit No. VI0040703 dated February 21, 1997.

4. **Additional Information:**
See Original TPDES Permit No. VI0040703 dated February 21, 1997.

5. **Derivation of Effluent Limits:**

EFFLUENT LIMITATION AND MONITORING REQUIREMENT			
POLLUTANT	LIMIT	MONITORING FREQUENCY	SAMPLE TYPE
OUTFALL 001			
Flow	14,440 gpd	Weekly	Flow meter
pH	6.5 to 8.5	Weekly	Grab
Total Organic Carbon	20 mg/L	Weekly	Grab
Total Suspended Solids (TSS)	40 mg/L	Weekly	Grab
Benzene	15 ug/L	Monthly*	Grab
Toulene	50 ug/L	Monthly*	Grab
Total Xylene	50 ug/L	Monthly*	Grab
Total BTX	100 ug/L	Monthly*	Grab
Lead	50 ug/L	Monthly*	Grab
Petroleum Hydrocarbons	15 mg/L	Quarterly*	Grab

* Initial weekly monitoring of the groundwater remediation system influent and effluent for two months. After two months, Esso will submit a report documenting the results.

A. CONDITIONS OF PERMIT

This permit is issued subject to the following conditions:

- In addition to required the discharge monitoring report form [EPA #3320-1], monthly data reports for the first three months are required to be submitted by Esso on the operation of the treatment system including any and all groundwater monitoring and air emission data. Following the third month report submission, unless DPNR notifies Esso otherwise, reports and the operation of the treatment system may be reduced to quarterly. In addition, a comprehensive semi-annual report is required.

- Expedited QA/QC lab results (entire data package) will be submitted directly to DPNR within seven days after QA/QC review for the first two months of operation. Thereafter, results will be submitted within 14 days of QA/QC review.

B. EFFLUENT LIMITATION AND MONITORING REQUIREMENTS

During the period beginning EDP and lasting through EDP + 5 years, the Permittee is authorized to discharge from Outfall(s) serial number(s) 001.

Such discharges shall be limited and monitored by the Permittee as specified below:

EFFLUENT LIMITATION AND MONITORING REQUIREMENT			
<u>POLLUTANT</u>	<u>LIMIT</u>	<u>MONITORING FREQUENCY</u>	SAMPLE TYPE
<u>OUTFALL 001</u>			
Flow	14,400 gpd	Weekly	Flow meter
pH	6.5 to 8.5	Weekly	Grab
Total Organic Carbon	20 mg/l.	Weekly	Grab
Total Suspended Solids (TSS)	40 mg/L	Weekly	Grab
Benzene	15 ug/L	Monthly*	Grab
Toulene	50 ug/l.	Monthly*	Grab
Total Xylene	50 ug/l.	Monthly*	Grab

Total BTX	100 ug/L	Monthly*	Grab
Lead	50 ug/L	Monthly*	Grab
Petroleum Hydrocarbons	15 mg/L	Quarterly*	Grab

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirement specified above shall be taken at the following specified locations (s):

For influent: from sampling port prior to entry into the treatment system.

For effluent: any point after the treatment process but prior to being discharged into the receiving waters.

* Initial weekly monitoring of the groundwater remediation system influent and effluent for two months. After two months, Esso is to submit a report documenting the results.

NOTE:

NO BACKWASH FROM ANY TREATMENT UNIT(S) FOR MAINTENANCE PURPOSES OR ANY OTHER REASONS SHALL BE DISCHARGED THROUGH THE AUTHORIZED OUTFALLS.

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GOVERNMENT OF THE VIRGIN ISLANDS OF THE UNITED STATES

Department of Planning & Natural Resources
Division of Environmental Protection
WATER GUT HOMES 1118
CHRISTIANSTED, ST. CROIX 00820-5065
(809) 773-0565

September 3, 1998

Ms. Alicia Barnes
Barnes and Associates, Inc.
P.O. Box 879 Kingshill
USVI 00851

RE: Soil Boring Permit and Well Drilling Permit for Esso Standard Oil, Esso Tutu Service Station, St. Thomas, USVI

Dear Ms. Barnes,

The Department of Planning and Natural Resources - Division of Environmental Protection (DPNR-DEP) is processing Esso Standard Oil applications for soil boring/well drilling permits at the following locations:

1. 6 well drilling permits : Esso Tutu Service Station.
2. 2 well drilling permits : Four Winds Plaza property.
3. 2 well drilling permits : Four Winds Plaza property.
4. 4 well drilling permits : Esso Tutu Service Station.

As you are aware, the permits can only be issued by order of the Commissioner. At your request, and in the interest of expediting site characterization/remedial activities at the above referenced sites on St. Thomas, permission is hereby granted to Soil Tech Corp. (WDL-013-98) P.O.Box 1704, Hato Rey Station, Puerto Rico, by DPNR-DEP to proceed pending receipt of the official permits.

Please note that you must ensure that Soil Tech Corp.comply with the provisions of Act No. 1488, section 1, of the Virgin Islands Code (12 VIC §157), as amended, dealing with the licensing of well drilling as a regular business or as an incident to any line of business activity; and must comply with the provisions of the Civil Rights Act of the Virgin Islands (Act No. 720, approved June 9, 1961) [10 VIC §§ 41-44].

Please advise Esso and Soil Tech that they must also comply with the provisions of 12 VIC §161 when sealing the soil borings upon completion of site investigative activities. You must notify DPNR-DEP at least two days prior to commencement of drilling activities. This temporary permit is valid from September 3 to October 3, 1998, pending receipt of the official permits.

Sincerely,

Austin Moorehead

Austin Moorehead
Director, DPNR-DEP

Government Of
The Virgin Islands Of The United States

DEPARTMENT OF PLANNING & NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL PROTECTION
Charlotte Amalie, St. Thomas, Virgin Islands

AIR POLLUTION CONTROL

■ AUTHORITY TO CONSTRUCT   PERMIT TO OPERATE

For: **ESSO Virgin Islands, Inc.**
Airport Terminal
St. Thomas, Virgin Islands 00804

Permit No.:**STT-755-B-98**   Date: **July 15, 1998**

Persuant to the provisions of Title 12, Chapter 9, Section 206, Sub-Section 20 of the Virgin Islands Code. This Permit is issued to:

ESSO Virgin Islands Inc.

For the operation of the following: **One (1) Soil Vapor Extraction System.**

Located at: **384 Estate Anna's Retreat, St. Thomas, Virgin Islands**

In accordance with the application dated: **September 25, 1997** and in conformity with the statements and supporting data entered therein, all of which are filed with the Department and are considered a part of this permit.

This permit shall be effective from the date of : **July 15, 1998** for a two year period ending on: **July 15, 2000.**

Commissioner, DPNR

Government Of
The Virgin Islands Of The United States

DEPARTMENT OF PLANNING & NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL PROTECTION
Charlotte Amalie, St. Thomas, Virgin Islands

AIR POLLUTION CONTROL

AUTHORITY TO CONSTRUCT ■ PERMIT TO OPERATE

For: **ESSO Virgin Islands, Inc.**
Airport Terminal
St. Thomas, Virgin Islands 00804

Permit No.:**STT-755-A-98** Date: **July 15, 1998**

Persuant to the provisions of Title 12, Chapter 9, Section 206, Sub-Section 20 of the Virgin Islands Code. This Permit is issued to:

ESSO Virgin Islands Inc.

For the operation of the following: **One (1) Shallow Tray Model 1330/1331 ground-water air stripper.**

Located at: **384 Estate Anna's Retreat, St. Thomas, Virgin Islands**

In accordance with the application dated: **September 25, 1997** and in conformity with the statements and supporting data entered therein, all of which are filed with the Department and are considered a part of this permit.

This permit shall be effective from the date of : **July 15, 1998** for a two year period ending on: **July 15, 2000.**

Commissioner, DPNR

Forensic Environmental Services, Inc.
113 John Robert Thomas Drive
The Commons at Lincoln Center
Exton, Pennsylvania 19341

Telephone: (610) 594-3940 Telecopier: (610) 594-3943

24 September 1998

Mr. Winston M.A. Williams Jr.
Air Pollution Control Program Supervisor
Department of Planning and Natural Resources
Foster Plaza 396-1
Anna's Retreat
St. Thomas, USVI 00802

Re: Soil Vapor Extraction Unit (A/C)
Ground-Water Air Stripper (A/C)
"Authority to Construct" Permit Nos. STT-755-A-98 and STT-755-B-98
Esso Tutu Service Station Remedial System

Dear Mr. Williams:

Forensic Environmental Services, Inc. (FES), on behalf of Esso Virgin Islands, Inc. (Esso), has received and reviewed the "Authority to Construct" Soil Vapor Extraction System and Ground-Water Air Stripper Air Pollution Control Permits issued on 15 July 1998 by the USVI Department of Planning and Natural Resources (DPNR) for the referenced site. After reviewing the permits, it is noted that modifications have been made to the original remedial system design/capacity since the original application was prepared and submitted to DPNR by FES on 25 September 1997. These alterations were the result of discussions between the U.S. EPA, DPNR, Esso, and FES, and were made with full regulatory approval.

As a result of the remedial system design/capacity changes, several revisions will be necessary to the two "Authority to Construct" Permit Nos. STT-755-A-98 and STT-755-B-98. The changes to the remedial system and the consequent effect on the applications and permits are outlined below. For your convenience, a copy of the original permit applications and Permit Nos. STT-755-A-98 and STT-755-B-98 are attached. Revised permit applications have been submitted in triplicate.

SOIL VAPOR EXTRACTION SYSTEM - AIR POLLUTION CONTROL PERMIT

The Soil Vapor Extraction (SVE) System will utilize 5 extraction wells operating at 15 to 20 cubic feet per minute (cfm) per well, and five biovent extraction (BE) wells operating at flow rates ranging from 3-5 cfm each. The expected average operating total flow for the SVE system will be 125 cfm with a maximum estimated flow rate of approximately 175 cfm. Vapor treatment for the SVE System will be provided by a catalytic-oxidizer (cat-ox) unit instead of vapor-phase carbon as specified in the original application.

Table 1a presents air emissions calculations based on average soil vapor concentrations obtained during on-site pilot testing at the expected average operating flow rate of 125 cfm and at the maximum SVE system capacity flow rate of 175 cfm. Table 1b presents air emissions calculations based on maximum soil vapor concentrations obtained during on-site pilot testing at flow rates of 125 cfm and 175 cfm. The latter conditions serve as the "worst-case" scenario (regarding maximum mass loading) for the SVE system. The cat-ox unit is designed to operate at a minimum removal efficiency of 95%; this will reduce projected contaminant concentrations in the vapor effluent to 0.043 lbs/hour at an SVE flow rate of 175 cfm.

A revised permit application, which includes equipment description, emissions calculations (Tables 1a and 1b), manufacturer's equipment specifications sheets, system schematic, and a process and instrumentation diagram (P&ID), is enclosed. The changes described above have resulted in the following modifications to the soil vapor extraction permit application and permit (original application and permit attached):

application:

SECTION A, ITEM 1:	"new process equipment and new air pollution control apparatus" is now selected
SECTION A, ITEM 3:	starting date October 1998, Est. completion 2002
SECTION B, ITEM 2:	vacuum blower, cat-ox unit
SECTION B, ITEM 3:	0.043 total pounds per hour
SECTION C:	(see Table 1c attached to permit application)
SECTION D, ITEM 1:	moisture knock-out, in-line filter, catalytic oxidation unit
SECTION D, ITEM 2:	minimum of 95%
SECTION D, ITEM 3:	approximately 15 feet
SECTION D, ITEM 4:	9.5 ft.
SECTION D, ITEM 5:	avg. 125 cfm, max. 175 cfm
SECTION D, ITEM 6:	560 ft. per minute
SECTION D, ITEM 7:	600°
SECTION D, ITEM 8:	Yes
SECTION D, ITEM 9:	N/A
SECTION D, ITEM 10:	$40,000

<u>air pollution control permit:</u>

SECTION II, ITEM f:	change to concentrations listed in this revision
SECTION II, ITEM g:	the maximum flow rate should be 10 gpm
SECTION II, ITEM k:	eliminate (no vapor-phase air control)
SECTION II, ITEM l:	eliminate (no vapor-phase air control)
SECTION II, ITEM m:	eliminate (no vapor-phase air control)
SECTION II, ITEM n:	eliminate (no vapor-phase air control)

FES greatly appreciates your prompt attention to this matter. It is our understanding that DPNR will be able to provide FES with a telefax copy of the revised permit within five business days of the receipt of this submission. Please contact us at your earliest convenience if this time frame is not possible. If you have any questions or concerns about the information provided here, please feel free to call us at 610-594-3940.

Sincerely,

FORENSIC ENVIRONMENTAL SERVICES, INC.

Robert W. Zei
Senior Hydrogeologist

Nick DeSalvo
Senior Project Manager

Attachments

cc: Giancarlo Villa, Esso Virgin Islands, Inc.
Carlos Figueroa, Esso Standard Oil Company (Puerto Rico)
Chad Stevens, Esso Virgin Islands, Inc.

permit:

INTRODUCTION:	substitute "catalytic oxidizer" for "vapor-phase carbon"
SECTION II, ITEM a:	change maximum flow rate of air to from 162.5 scfm to 175 scfm
SECTION II, ITEM c:	(no change - already lists cat-ox)

GROUND-WATER AIR STRIPPER - AIR POLLUTION CONTROL PERMIT

The Ground-Water Extraction (GWE) System will utilize 4 perched water and 4 shallow bedrock ground-water extraction wells. Ground-water extraction rates are expected to range from 0.25 to 0.50 gallons per minute (gpm) for each perched water well, and from 0.50 to 1.0 gpm for each shallow bedrock well (total flow rate of 6 gpm), The expected initial operating flow for the GWE system will be 6 gpm with a maximum estimated flow rate of approximately 10 gpm. During the operational life of the system, total process flow rates are expected to decrease as the perched water zone is dewatered.

Ground water will be processed through a treatment system that includes an oil/water separator, sediment filter, and a low-profile ground-water air stripper. Aqueous-phase granular activated carbon treatment is added as a precautionary measure. Off-gas from the ground-water air stripper will be discharged directly to the atmosphere. The ground-water air stripper is designed to operate at a maximum air flow discharge rate of 300 scfm. The estimated total concentration of volatile organic compounds in the air stripper off-gas under normal operating conditions is 0.08 lbs/hour, and 0.13 lbs/hour at the maximum extraction rate of 10 gpm. Air emission calculations for the air stripper are provided in Table 2a.

A revised permit application, which includes equipment description, emissions calculations (Tables 1a and 1b), manufacturer's equipment specifications sheets, system schematic, and a P&ID, is enclosed. The changes described above have resulted in the following modifications to the ground-water air stripper air pollution control permit application and permit (original application and permit attached):

application:

SECTION A, ITEM 3:	starting date October 1998, Est. completion 2008
SECTION B, ITEM 3:	0.08 total pounds per hour
SECTION C:	(see Table 2b attached)
SECTION D, ITEM 1:	substitute "NONE" for "Dual-Bed Granular Activated Carbon system" (This entry was in error in the original application. Due to the de minimus mass discharge neither the original or the revised application incorporated off-gas treatment.)
SECTION D, ITEM 2:	N/A
SECTION D, ITEM 5:	300 cu. ft. per min.
SECTION D, ITEM 6:	1500 ft. per min.
SECTION D, ITEM 7:	80°

air pollution control permit:

SECTION II, ITEM f:	change to concentrations listed in this revision
SECTION II, ITEM g:	the maximum flow rate should be 10 gpm
SECTION II, ITEM k:	eliminate (no vapor-phase air control)
SECTION II, ITEM l:	eliminate (no vapor-phase air control)
SECTION II, ITEM m:	eliminate (no vapor-phase air control)
SECTION II, ITEM n:	eliminate (no vapor-phase air control)

FES greatly appreciates your prompt attention to this matter. It is our understanding that DPNR will be able to provide FES with a telefax copy of the revised permit within five business days of the receipt of this submission. Please contact us at your earliest convenience if this time frame is not possible. If you have any questions or concerns about the information provided here, please feel free to call us at 610-594-3940.

Sincerely,

FORENSIC ENVIRONMENTAL SERVICES, INC.

Robert Zei

Robert W. Zei
Senior Hydrogeologist

Nick DeSalvo

Nick DeSalvo
Senior Project Manager

Attachments

cc: Giancarlo Villa, Esso Standard Oil Company (Puerto Rico)
Carlos Figueroa, Esso Standard Oil Company (Puerto Rico)
Chad Stevens, Esso Virgin Islands, Inc.

GOVERNMENT OF
THE VIRGIN ISLANDS OF THE UNITED STATES
DEPARTMENT OF PLANNING AND NATURAL RESOURCES
AIR POLLUTION CONTROL

APPLICATION

AUTHORITY TO CONSTRUCT AND PERMIT TO OPERATE

INSTRUCTIONS

A. This application must be filled out completely and must be filed in TRIPLICATE.

B. Applications are incomplete unless accompanied by DUPLICATE copies of all plans, specifications and drawings required. Details required for specific equipment are listed on separate forms which are available upon request.

INCOMPLETE APPLICATIONS ARE NOT ACCEPTABLE

Date of Application: REVISED SEPT. 24, 1998

APPLICATION INFORMATION

1. Permit to be issued to: (Business License Name of Corporation, Company, Individual Owner or Governmental Agency that is to operate the Equipment):

ESSO VIRGIN ISLANDS, INC

2. Mailing Address:

P.O. Box ESSO TERMINAL City CHARLOTTE AMALIE Island ST. THOMAS Zip 00801

3. Address at which the equipment is to be operated:

Number 384 Street ESTATE ANNA'S RETREAT Island ST. THOMAS Zip 00802

4. Type of Organization: Corp. X Partnership ____ Individual Owner ____ Governmental Agency ____

5. General Nature of Business:

PETROLEUM RETAIL SERVICE STATION

6. Equipment Description: Pursuant to the Provisions of the U.S. Virgin Islands Code and the Rules and Regulations of the Air Pollution Control Region, application is hereby made for authority to construct and permit to operate the following equipment:

AIR STRIPPER GROUND-WATER TREATMENT UNIT
(ESSO TUTU GROUND-WATER REMEDIATION)

Sec. A	1. ☐ New process equipment and new air pollution control apparatus ☐ New air pollution control apparatus on existing process equipment ☒ New process equipment with no control apparatus ☐ Other: _____ 2. Prior permit numbers covering this installation. Specify. NOT APPLICABLE 3. Estimated starting date OCTOBER 1998 Est. completion 2008
Sec. B	1. Description of operation AIR STRIPPER TREATMENT FOR REMEDIATION OF GROUND WATER 2. Identify process equipment AIR STRIPPER 3. Raw materials (names) GROUND WATER CONTAMINATED WITH PETROLEUM PRODUCT Total pounds per hour 0.08 (SEE ATTACHED TABLE 2A) Total pounds per batch — 4. Operating procedure: ☒ Continuous: 24 hrs. per day 7 days per ☒ week ☐ month ☐ Batch: — hrs. per batch — batches per ☐ day ☐ week
	Physical and chemical nature of air contaminants which must evolve from operation and be emitted into the open air:

Sec. C

Air Contaminants	Amounts of Contaminants: With Control Apparatus	Amounts of Contaminants: Without Control Apparatus
(SEE ATTACHED TABLE 2B		
FOR A COMPLETE LIST OF POTENTIAL		
AIR CONTAMINANTS)		

Sec. D	1. Describe air pollution control apparatus NONE
	2. Efficiency of control apparatus: 99.9 %
	3. Height of discharge above ground 20 ft.
	4. Distance from discharge to nearest property line APPROX. 15 ft.
	5. Volume of gas discharged into open air 300 cu. ft. per min. at stack conditions.
	6. Exit linear velocity at point of discharge 1500 ft. per min. at stack conditions.
	7. Temperature at point of discharge 80 °F.
	8. Will emissions comply with existing local requirements? YES
	9. Initial cost of control apparatus $ 15,000
	10. Estimated annual operating cost $ 2,500

This application is submitted in accordance with the provisions of the Virgin Islands Code 12, Chapter 9, Air Quality Control Regulations Section 206-20, and to the best of my knowledge and belief is true and correct.

ESSO VIRGIN ISLANDS INC
CYRIL E. KING
AIRPORT TERMINAL
ST. THOMAS USVI
Mailing Address

00804
Zip Code

Signature - all copies

Name (print or type)

Title

Telephone No.

AUTHORITY TO CONSTRUCT AND PERMIT TO OPERATE

[illegible] APPROVED

Date [illegible] Approved by

Permit No. [illegible] Supervisor Permits & Compliance

Esso Tutu Service Station
Ground-Water Remedial System
Air Pollution Control Permit
Equipment Description

System Description

As part of the USEPA CERCLA Record of Decision, Esso Virgin Islands, Inc. is required to remediate shallow ground water beneath the Esso Tutu Service Station. The subject site is located on Route 38, Anna's Retreat, St. Thomas, adjacent to Four Winds Plaza (Figure 1).

The proposed remedial program will involve the extraction of ground water from four overburden and four shallow bedrock wells. The four overburden wells will be installed to a depth of approximately 15 feet and utilized to extract ground water at a rate of 0.5 gallons per minute (gpm) per well (total overburden flow rate of 2.0 gpm). The four shallow bedrock wells will be installed to a depth of approximately 60 feet and utilized to extract ground water at a rate of 1.0 gallons per minute (gpm) per well (total shallow bedrock flow rate of 4.0 gpm). During initial operation, the expected ground-water extraction rate will be approximately 6.0 gpm (the SVE moisture knock-out system may also contribute up to 1.0 gpm) with a maximum anticipated flow rate of 10 gpm. Total process flow rates are expected to decline over time as the overburden is dewatered.

Extracted ground water will be transferred to an oil/water separator, facilitating the separation of phase-separated hydrocarbons (if present) and water. Phase-separated hydrocarbons (if present) will be disposed in accordance with USEPA and DPNR protocol. Ground water will be directed to a batch holding tank and processed through a treatment system that will involve the following components:

1. Sediment filter,
2. Low profile air stripper, and
3. Aqueous-phase granular activated carbon.

The above components are illustrated in the attached "Process Flow Diagram" and "Process & Instrumentation Diagram".

Equipment Description

The air stripper unit is the only component of the ground-water remedial system that will emit gases to the atmosphere. A ShallowTray-brand Model 2341 will be utilized for the Esso Tutu treatment system. A discharge pipe will be attached to the air stripper to elevate the point of emission to a height of 20 feet above ground surface.

Calculations summarizing expected effluent concentrations in the air stripper off-gas are included in Table 2a. Assuming 100% air stripper efficiency ("worst-case with respect to maximum atmospheric mass loading), these calculations indicate that the concentration of total volatile organic compounds in the off-gas stream will be approximately 0.078 pounds per hour during average flow (6 gpm), and a maximum of 0.130 pounds per hour during maximum flow (10 gpm). Compliance monitoring will include the collection of aqueous-phase samples for analytical testing at the same frequency as that outlined in the TPDES Permit #VI00040703 for the site. A schedule for compliance monitoring during the first 12 months of system operation is presented in Table 2c. The emission rate will be calculated on a monthly basis using the following equation:

$$\text{Max. Emission Rate (\#/hr)} = \text{Max. Flow (gal/min)} \times \text{Max. Concentration (ppm)} \times 8.34\ (\text{\#/gal}) \times 60\ (\text{min/hr}) \times 10^{-6}$$

Air stripper off-gas will be discharged directly to the atmosphere. Off-gas concentrations will be field-monitored during operation of the remedial system to ensure that effluent concentrations do not significantly exceed those predicted. DPNR will be copied on all air emission monitoring data.

Table 2a
Air Emissions Calculations
Ground-Water Extraction System (Air Stripper Off-Gas)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Compound	Weighted Flow Concentration			Contaminant Mass @ 10 gpm			Total Contaminant Mass (lbs/hr)	
	µg/L	mg/L	gm/L	gm/gal	gm/min	gm/hr	6 gpm	10 gpm
Benzene	2222	2.222	0.0022	0.0084	0.0841	5.0456	0.0070	0.0116
Toluene	134	0.134	0.0001	0.0005	0.0051	0.3036	0.0004	0.0007
Ethylbenzene	684	0.684	0.0007	0.0026	0.0259	1.5541	0.0021	0.0036
Xylenes	1856	1.856	0.0019	0.0070	0.0702	4.2144	0.0058	0.0097
MTBE	19939	19.939	0.0199	0.0755	0.7547	45.2813	0.0624	0.1040
Tetrachloroethene	12	0.012	1.20E-05	4.54E-05	0.0005	0.0273	3.75E-05	0.0001
Trichloroethene	3	0.003	3.00E-06	1.14E-05	0.0001	0.0068	9.39E-06	1.56E-05
1,2 Dichloroethene (total)	23	0.023	2.30E-05	0.0001	0.0009	0.0522	0.0001	0.0001
Vinyl Chloride	3	0.003	3.00E-06	1.14E-05	0.0001	0.0068	9.39E-06	1.56E-05
Acetone	2	0.002	2.00E-06	7.57E-06	0.0001	0.0045	6.26E-06	1.04E-05
Methylene Chloride	14	0.014	1.40E-05	0.0001	0.0005	0.0318	4.38E-05	0.0001
	A	B = A/1000	C = B/1000	D = Cx3.785	E = Dx10	F = Ex60	G = H/0.6	H = F/435.5
Total estimated air emission in pounds/hour (assumes 100% air stripper efficiency) =							**0.078**	**0.130**

L = liters, µg = microgram, mg = milligrams, gm = grams, gal = gallons, gpm = gallons per minute, min = minutes, lbs = pounds, hr = hour
Weighted flow concentrations assume the four "perched water" wells will provide 33% of the total flow and the four "deep" wells will provide 67% of the total flow.
Weighted contaminant concentrations based on quantitative ground-water samples collected at the site in September/October 1996.
Estimate assumes air stripper will operation with a 100% treatment efficiency.

Table 2b
Air Emissions Calculations
Ground-Water Extraction System (Air Stripper Off-Gas)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

SECTION C			
Air Contaminants	Amounts of Contaminants		
	With Control Apparatus (lbs/hr)	Without Control Apparatus (lbs/hr)	
		6 gpm	10 gpm
Benzene	not applicable	0.0070	0.0116
Toluene	not applicable	0.0004	0.0007
Ethylbenzene	not applicable	0.0021	0.0036
Xylenes	not applicable	0.0058	0.0097
MTBE	not applicable	0.0624	0.1040
Tetrachloroethene	not applicable	3.75E-05	0.0001
Trichloroethene	not applicable	9.39E-06	1.56E-05
1,2 Dichloroethene (total)	not applicable	0.0001	0.0001
Vinyl Chloride	not applicable	9.39E-06	1.56E-05
Acetone	not applicable	6.26E-06	1.04E-05
Methylene Chloride	not applicable	4.38E-05	1.00E-04
TOTAL	not applicable	0.08	0.13

Assumptions used to estimate discharge in pounds per hour (lbs/hr) are identified in Table 2a.

Average operational system flow rate is estimated at 6 gallons per minute (gpm); maximum estimated system flow rate is 10 gpm.

Table 2c
Schedule of Compliance Monitoring
Ground-Water Extraction System (Air Stripper Off-Gas)
Air Pollution Control Permit
Esso Tutu Service Station
St. Thomas, U.S.V.I.

	Sampling Frequency
Time From System Start-up	**Quantitative Sampling (Aqueous Phase) (Laboratory)**
0 - 2 months	Weekly; influent and effluent for VOCs and TPH
2 months - 6 months	Monthly; influent and effluent for VOCs and TPH
6 months - 12 months	Monthly; influent and effluent for VOCs Quarterly; influent and effluent for TPH

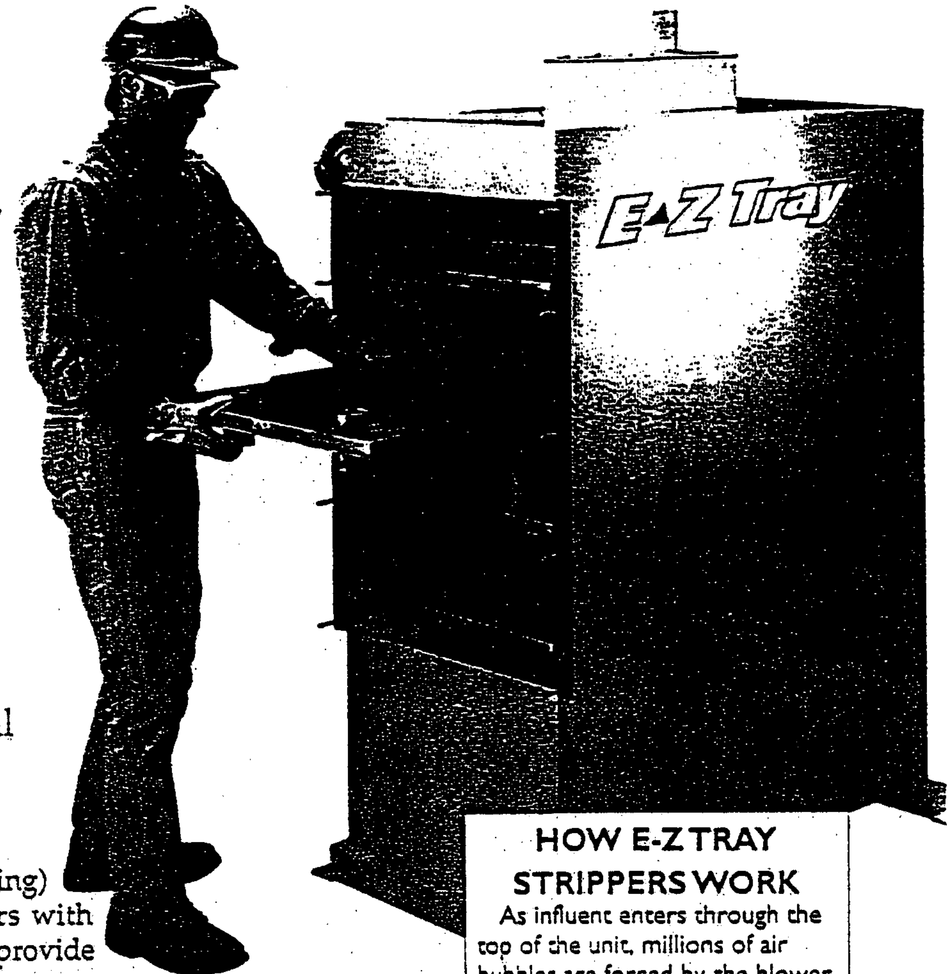
VOCs = volatile organic compounds (analysis via EPA Method 8240)
TPH = total petroleum hydrocarbons (analysis via EPA Method 8015A)
influent = pre-air stripper aqueous sample; effluent = system discharge aqueous sample
Influent and effluent aqueous-phase samples will be used to calculate the contaminant mass removed and discharged in the vapor-phase by the air stripper.
The sampling frequency outlined above is based on ground-water system discharge sampling requirements stipulated in the site's TPDES Permit #VI0040703.

E-Z Tray™

Removable Tray Air Strippers

UNIQUE FRONT ACCESS DESIGN PROVIDES LONG-TERM O&M SAVINGS

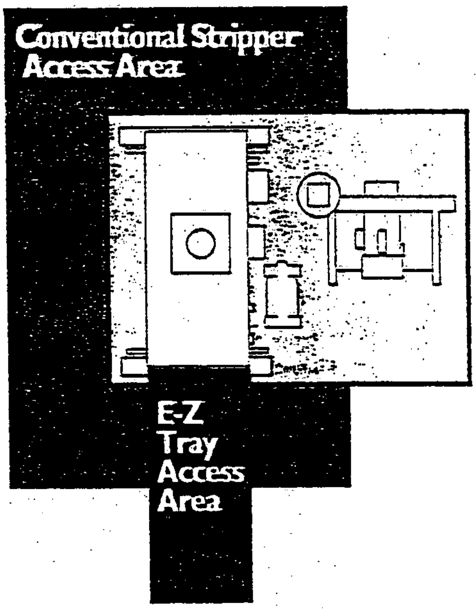
- Single-person cleaning
- Easy accessibility
- Space and construction cost savings
- High-efficiency VOC removal



THE MOST PRACTICAL, ECONOMICAL STRIPPERS

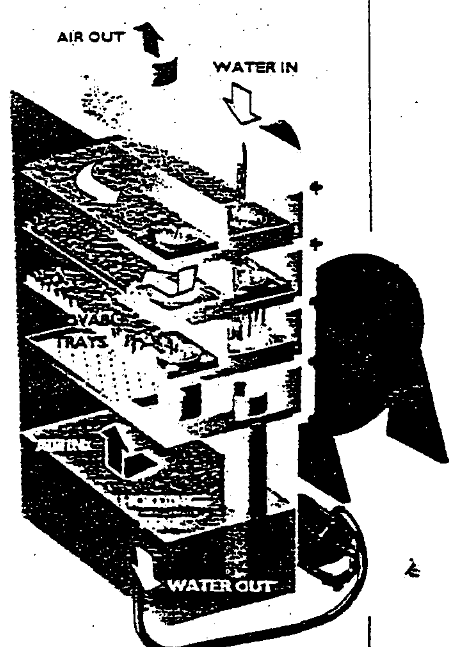
E-Z Tray™ air strippers (patent pending) are the only high-performance strippers with lightweight, front-slideout trays. They provide many advantages:

- One-person cleaning can save thousands of dollars per year on cleaning costs.
- Front serviceability—with just 4" clearance required at back and sides—allows positioning in corners, tight access or low clearance locations—saving thousands more by cutting building space needs 10-40%.
- Forced-draft air bubble technology delivers rapid, efficient VOC removal (to 99.999%) and generates a self-cleaning action that fights fouling.



HOW E-Z TRAY STRIPPERS WORK

As influent enters through the top of the unit, millions of air bubbles are forced by the blower pressure up through the perforated trays, vigorously aerating the water to a froth and removing volatile contaminants as gravity pulls the water down through each tray. This simple, revolutionary technology delivers up to 99.999% removal, while the low maintenance and easy access cut O & M costs dramatically.



MODELS TO FIT YOUR NEEDS, SPACE, AND BUDGET

E-Z tray strippers are available in four or six-tray configurations, with maximum flow ratings from 1-25 GPM (4-100 LPM) through 1-150 GPM (4-600 LPM).

Call today to talk to a QED Applications Specialist about which E-Z Tray Stripper is right for your project—<u>and find out how much you'll save.</u>

UP TIME CERTIFIED TREATMENT EQUIPMENT

800-624-2026

QED Environmental Systems, Inc. 6095 Jackson Road, P.O. Box 3726, Ann Arbor, MI 48106
313-995-2547 FAX 313-995-1170

E-Z Tray™

STANDARD ITEMS

- One Piece Shell with Integral Sump
- Stainless Steel Trays
- Quick-Access Front Hatch Assembly
- Clear PVC Liquid Level Sight Gauge
- Poly Mesh Demister
- Pre-Piping
- Epoxy Coated Mild Steel Construction

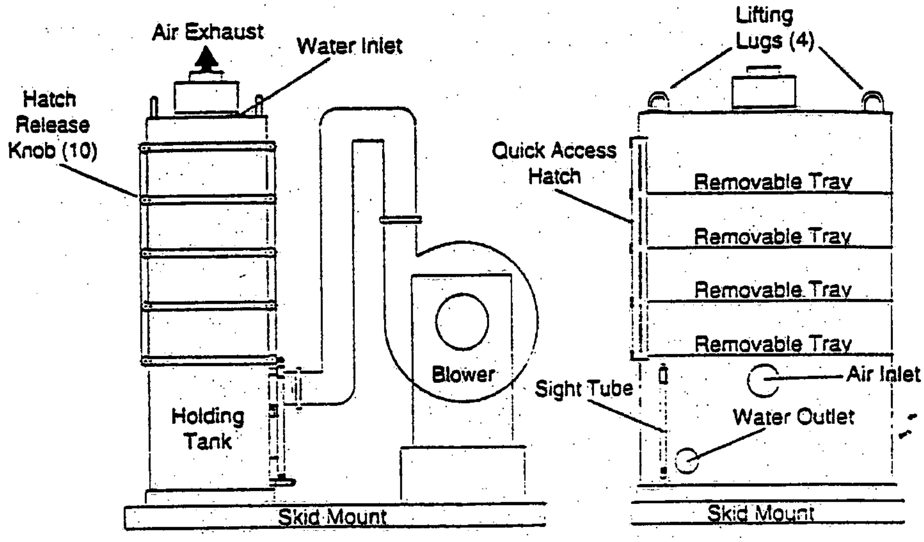
E-Z TRAY OPTIONS

- EXP or TEFC Blower & Pump Motors
- Spare Trays
- Control Panel
- Effluent Pump
- Pump Controls
- Additional Fittings
- Temp & Pressure Gauges
- Water Flow Meter
- Air Flow Meter
- Pre-Wiring
- Intrinsically Safe Sensors
- Base Unit Pre-plumbed to Blower
- Skid Mounting
- Stainless Steel Shell Construction
- Six Tray units

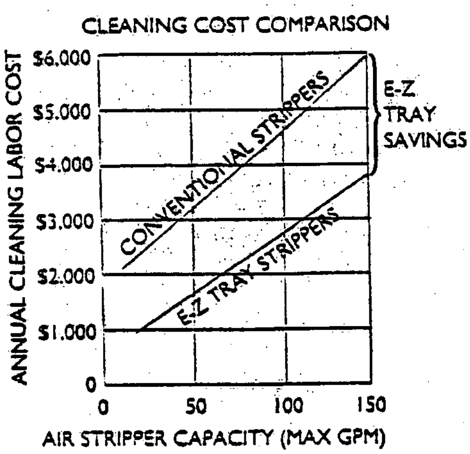
EZ TRAY AIR STRIPPER SPECIFICATIONS

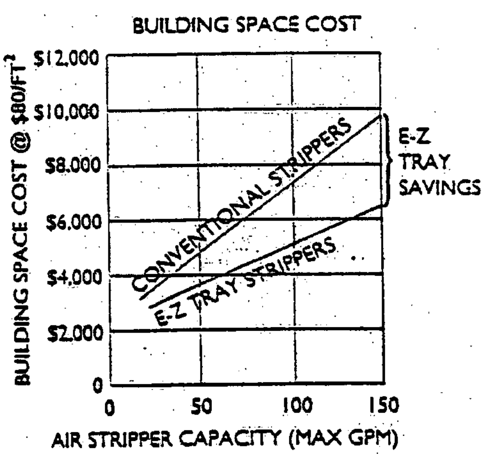
Model	Dimensions (in inches) H	L	W	Dry Wt.	Oper Wt.	Dry Wt. Per Tray	Flow Range (GPM)
4.4	80.50	29.0	30	630 lbs	985 lbs	29 lbs	1-25
6.4	80.50	38.5	30	790 lbs	1285 lbs	40 lbs	1-35
8.4	80.75	50.5	30	955 lbs	1,580 lbs	50 lbs	1-50
12.4	81.00	75.0	30	1,165 lbs	2,105 lbs	74 lbs	1-75
16.4	81.00	50.5	55	1,625 lbs	2,870 lbs	50 lbs	1-100
24.4	81.00	75.0	55	2,100 lbs	3,980 lbs	74 lbs	1-150

Note: Specifications are for standard four-tray models. Consult factory for six-tray model specifications.



COST COMPARISON GRAPHS





Note. These are average cleaning costs, based on moderate levels of fouling requiring 12 cleanings per year at a labor cost of $40.00/hour. Actual cost will vary depending on changes in these factors. This graph assumes every other Latch-Tray cleaning will require full disassembly, with internal spray-wand cleaning only in alternate months. Each E-Z Tray cleaning includes tray removal.

STANDARD HOOK-UP REQUIREMENTS

Model	Water Inlet	Water Outlet	Blower Inlet	Exhaust Outlet	Water Gauge/Drain	Blower HP (Std.)
4.4	2" FNPT	3" FNPT	4" Flange	4.50" O.D. Pipe	1" FNPT	3.0 HP
6.4	3" FNPT	4" FNPT	6" Flange	6.63" O.D. Pipe	1" FNPT	5.0 HP
8.4	3" FNPT	4" FNPT	6" Flange	6.63" O.D. Pipe	1" FNPT	5.0 HP
12.4	4" FNPT	4" FNPT	6" Flange	6.63" O.D. Pipe	1" FNPT	7.5 HP
16.4	6" FNPT	4" FNPT	6" Flange	6.63" O.D. Pipe	1" FNPT	7.5 HP
24.4	6" FNPT	6" FNPT	8" Flange	8.63" O.D. Pipe	1" FNPT	15 HP

EZ Tray System Specification Data

Fill in and fax this section to QED to help determine which model & accessories will best meet your project needs.

SITE NAME AND LOCATION (optional) ____________

SITE TYPE (gas station, landfill, factory, etc.) ____________

NAME ____________

COMPANY ____________

ADDRESS ____________

____

CITY ____________

STATE / ZIP ____________

PHONE ____________

FAX ____________

Maximum system flow (gpm) ______

Water temperature (°F) ______

Air temperature (°F) ______

Contaminants	Influent (ppb)	Effluent Req'd
Benzene	______	______
Toluene	______	______
Ethylbenzene	______	______
Xylene	______	______
______	______	______
______	______	______
______	______	______

Stripper material:
- ☐ Epoxy/steel ☐ HDPE
- ☐ Stainless steel

Air discharge treatment ☐ Yes ☐ No
- ☐ Vapor phase carbon
- ☐ Thermal or catalytic oxidation

Iron sequestering agent ☐ Yes ☐ No

Site concerns ____________

QED Environmental Systems, Inc. 6095 Jackson Road, P.O. Box 3726, Ann Arbor, MI 48106

ShallowTray
low profile air strippers

DRAFT

System Performance Estimate

Client and Proposal Information:

Forensic Environmental

Model Chosen: 2300
Water Flow Rate: 10.0 gpm
Air Flow Rate: 300 cfm
Water Temp: 60.0 F
Air Temp: 60.0 F
A/W Ratio: 224.4
Safety Factor: None

Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal *
Benzene	2250 ppb 15 ppb	30 ppb 0.011105 98.6701%	1 ppb 0.011250 99.9823%	<1 ppb 0.011255 99.9998%	<1 ppb 0.011255 100.0000%
MTBE	20000 ppb 1000 ppb	4364 ppb 0.078214 78.1819%	953 ppb 0.095277 95.2397%	208 ppb 0.099004 98.9614%	46 ppb 0.099814 99.7734%
p-Xylene	1900 ppb 50 ppb	25 ppb 0.009379 98.7294%	1 ppb 0.009499 99.9839%	<1 ppb 0.009504 99.9998%	<1 ppb 0.009504 100.0000%
Toluene	150 ppb 50 ppb	3 ppb 0.000735 98.3680%	<1 ppb 0.000750 99.9734%	<1 ppb 0.000750 99.9996%	<1 ppb 0.000750 100.0000%
Ethyl Benzene	700 ppb 50 ppb	8 ppb 0.003462 98.8798%	<1 ppb 0.003501 99.9874%	<1 ppb 0.003502 99.9999%	<1 ppb 0.003502 100.0000%
Trichloroethylene	5 ppb 1 ppb	<1 ppb 0.000025 99.7067%	<1 ppb 0.000025 99.9991%	<1 ppb 0.000025 100.0000%	<1 ppb 0.000025 100.0000%
Tetrachloroethylene	15 ppb 1 ppb	<1 ppb 0.000075 99.8327%	<1 ppb 0.000075 99.9997%	<1 ppb 0.000075 100.0000%	<1 ppb 0.000075 100.0000%
1,1-Dichloroethylene	25 ppb 1 ppb	<1 ppb 0.000124 99.4946%	<1 ppb 0.000125 99.9974%	<1 ppb 0.000125 100.0000%	<1 ppb 0.000125 100.0000%
Vinyl Chloride	5 ppb 1 ppb	<1 ppb 0.000025 99.9822%	<1 ppb 0.000025 100.0000%	<1 ppb 0.000025 100.0000%	<1 ppb 0.000025 100.0000%

DRAFT

Page 2

Contaminant	Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 * Effluent Water Air(lbs/hr) % removal
Acetone	5 ppb 1 ppb	4 ppb 0.000005 20.8477%	4 ppb 0.000005 37.3491%	3 ppb 0.000010 50.4104%	2 ppb 0.000015 60.7487%

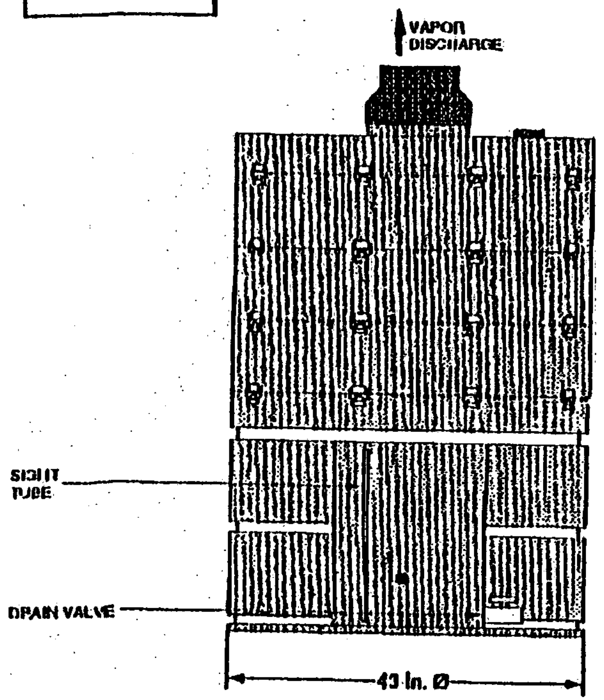
Due to its miscibility with water, acetone removal is difficult to predict. Call your neep representative for more in

Contaminant	Influent Effluent Target	Model 2311	Model 2321	Model 2331	Model 2341
Methylene Chloride	15 ppb 1 ppb	1 ppb 0.000070 98.0893%	<1 ppb 0.000075 99.9635%	<1 ppb 0.000075 99.9993%	<1 ppb 0.000075 100.0000%

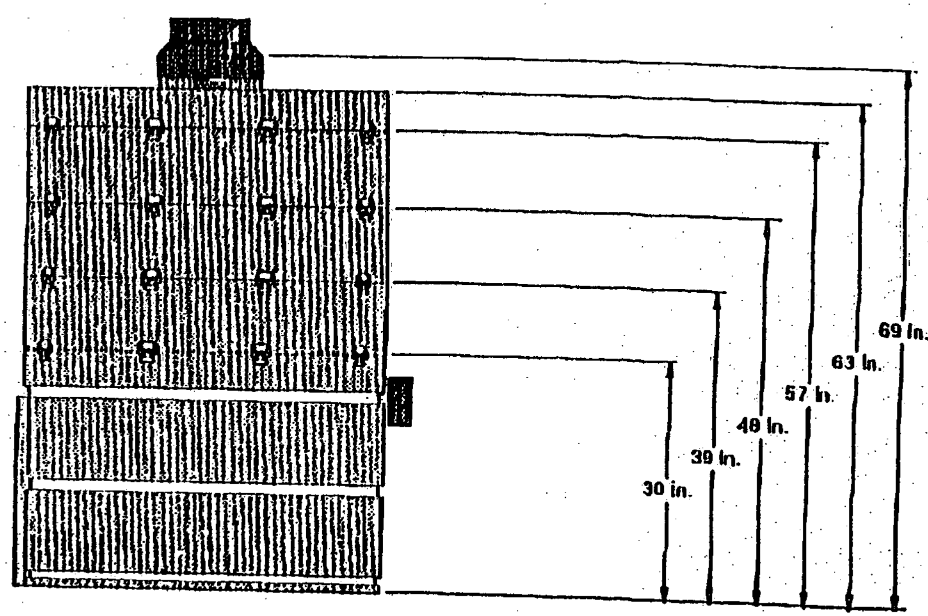
This report has been generated by ShallowTray Modeler software version 2.1W. This software is designed to assist a skilled operator in predicting the performance of a ShallowTray air stripping system. North East Environmental Products, Inc. is not responsible for incidental or consequential damages resulting from the improper operation of either the software or the air stripping equipment.
Report generated: 9/16/1998

MINIMUM SERVICE	
FRONT	1.5 ft.
TOP	12 in.
REAR	1.5 ft.
LEFT	2 ft.
RIGHT	2 ft.

FRONT



RIGHT SIDE



BASIC SYSTEM

- ✓ SUMP TANK
- ✓ STRIPPER TRAYS
- BLOWER
- ✓ MIST ELIMINATOR
- ✓ PIPING
- ✓ SPRAY NOZZLE
- ✓ WATER LEVEL SIGHT TUBE
- ✓ GASKETS
- ✓ LATCHES

OPTIONAL ITEMS

- ___ FRAME
- ___ AIR PRESSURE GAUGE
- ___ DISCHARGE PIPING
- ___ DISCHARGE PUMP
- ___ FEED PUMP
- ___ ADDITIONAL BLOWER
- ___ EXPLOSION PROOF MOTOR(S)
- ___ BLOWER START/STOP PANEL
- ___ CONTROL PANEL
- ___ MAIN DISCONNECT SWITCH
- ___ I.S. COMPONENTS/REMOTE MOUNT
- ___ INTERMITTENT OPERATION
- ___ STROBE LIGHT
- ___ ALARM HORN
- ___ POWER LAPSE INDICATOR
- ___ LOW AIR PRESSURE ALARM SWITCH
- ✓ HIGH WATER LEVEL ALARM SWITCH
- ✓ DISCHARGE PUMP LEVEL SWITCH
- ___ WATER PRESSURE GAUGE(S)
- ___ DIGITAL WATER FLOW INDICATOR
- ___ AIR FLOW METER
- ___ TEMPERATURE GAUGE(S)
- ___ LINE SAMPLING PORTS
- ___ AIR BLOWER SILENCER
- ___ WASHER WAND
- ___ AUTO DIALER

NOTE:

1. THIS DRAWING IS REPRESENTATIVE OF A TYPICAL CONFIGURATION SIMILAR TO THE UNIT REQUIRED, AND IS NOT INTENDED FOR ENGINEERING DESIGN OR LAYOUT. PLEASE CONTACT YOUR NEEP REPRESENTATIVE FOR DETAILED DESIGN INFORMATION.

CONNECTION INFORMATION

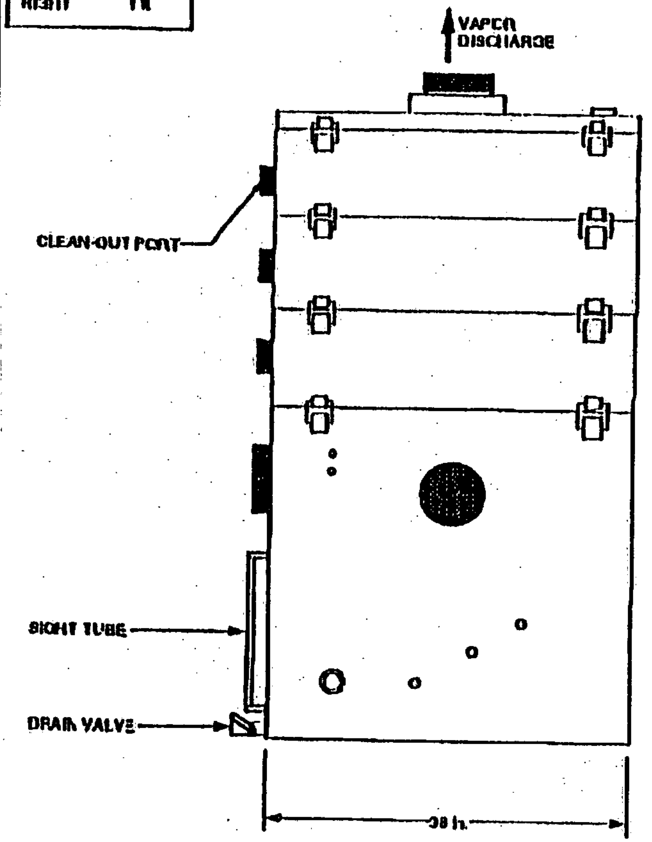
ITEM	SIZE
GRAVITY DISCHARGE	2 in. Ø SOCKET, PVC80
DISCHARGE PUMP	3/4 in. Ø FNPT
WATER INLET	1-1/4 in. Ø FNPT
AIR EXHAUST NOZZLE	8 in. Ø STUB W/8x8 CPLG

NORTH EAST ENVIRONMENTAL PRODUCTS, INC.
17 TECHNOLOGY DRIVE
WEST LEBANON, NEW HAMPSHIRE 03784
PHONE: 603-298-7061 FAX: 603-298-7063

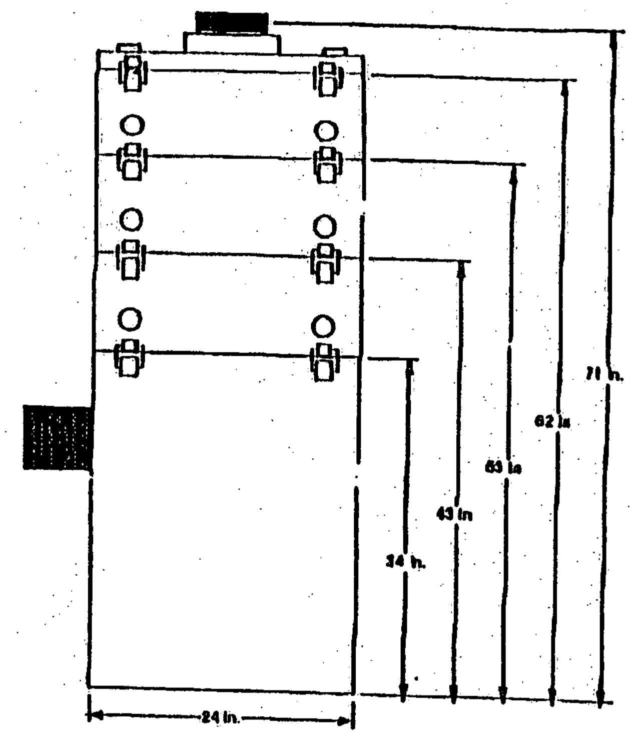
DRAWING NAME:	ShallowTray® Model 2330-P
DRAWING #:	Proposal #697908
DRAWN: DCS	CUSTOMER: Independent Equip: Forenelo, USVI
DATE: 6/20/97	SCALE: NTS / SIZE: A / SHEET: 1 OF 1

MINIMUM CLEARANCE	
FRONT	1.5 ft.
TOP	12 in.
REAR	N/A
LEFT	3.5 ft.
RIGHT	1 ft.

FRONT



RIGHT SIDE



BASIC SYSTEM

- ✓ SUMP TANK
- ✓ STRIPPER TRAYS
- __ BLOWER
- ✓ MIST ELIMINATOR
- ✓ PIPING
- ✓ SPRAY NOZZLE
- ✓ WATER LEVEL SIGHT TUBE
- ✓ GASKETS
- ✓ LATCHES

OPTIONAL ITEMS

- __ FRAME
- __ AIR PRESSURE GAUGE
- __ DISCHARGE PIPING
- __ DISCHARGE PUMP
- __ FEED PUMP
- __ ADDITIONAL BLOWER
- __ EXPLOSION PROOF MOTOR(S)
- __ BLOWER START-STOP PANEL
- __ CONTROL PANEL
- __ MAIN DISCONNECT SWITCH
- __ I.S. COMPONENTS REMOTE MOUNT
- __ INTERMITTENT OPERATION
- __ STROBE LIGHT
- __ ALARM HORN
- __ POWER LAPSE INDICATOR
- __ LOW AIR PRESSURE ALARM SWITCH
- ✓ HIGH WATER LEVEL ALARM SWITCH
- ✓ DISCHARGE PUMP LEVEL SWITCH
- __ WATER PRESSURE GAUGE(S)
- __ DIGITAL WATER FLOW INDICATOR
- __ AIR FLOW METER
- __ TEMPERATURE GAUGE(S)
- __ LINE SAMPLING PORTS
- __ AIR BLOWER SILENCER
- __ WASHER WAND
- __ AUTO DIALER

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CONNECTION INFORMATION

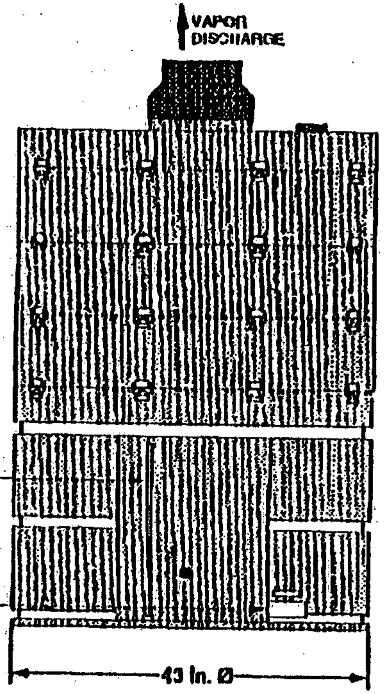
ITEM	SIZE
GRAVITY DISCHARGE	3 in. Ø SOCKET, PVC80
DISCHARGE PUMP	3/4 in. Ø FNPT
WATER INLET	2 in. Ø FNPT
AIR EXHAUST NOZZLE	6 in. Ø STUB w/6 in. CPLG

NORTH EAST ENVIRONMENTAL PRODUCTS, INC.
17 TECHNOLOGY DRIVE
WEST LEBANON, NEW HAMPSHIRE [illegible]
PHONE: [illegible] FAX: [illegible]

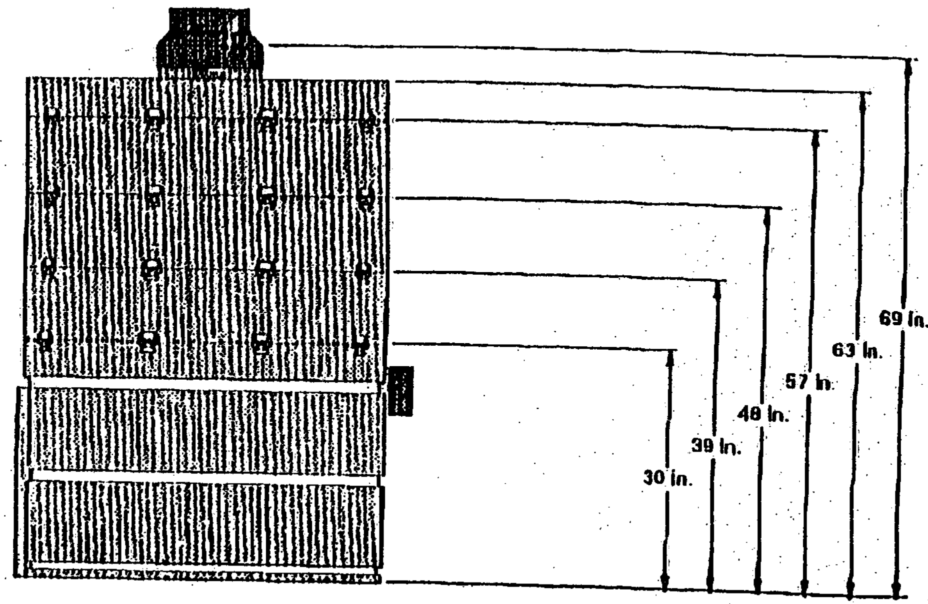
TOLERANCES UNLESS OTHERWISE [illegible]	DRAWING NAME: ShallowTray® Model 2330
	DRAWING #: Proposal # 697906
DRAWN: SAC	CUSTOMER: Independent Equip: Forensic, USVI
DATE: 8/20/97	SCALE: NTS · SIZE: A · SHEET 1 OF 1

MINIMUM CLEARANCE	
FRONT	1.5 ft.
TOP	12 in.
REAR	1.5 ft.
LEFT	2 ft.
RIGHT	2 ft.

FRONT



RIGHT SIDE



BASIC SYSTEM

- ✓ SUMP TANK
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- BLOWER
- ✓ MIST ELIMINATOR
- ✓ PIPING
- ✓ SPRAY NOZZLE
- ✓ WATER LEVEL SIGHT TUBE
- ✓ GASKETS
- ✓ LATCHES

OPTIONAL ITEMS

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CONNECTION INFORMATION

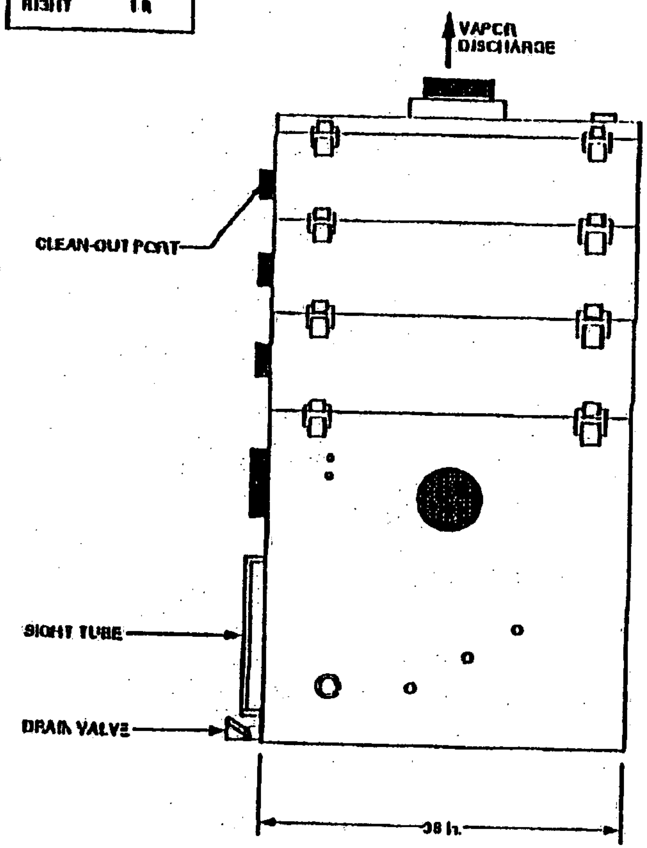
ITEM	SIZE
GRAVITY DISCHARGE	2 in. Ø SOCKET, PVC80
DISCHARGE PUMP	3/4 in. Ø FNPT
WATER INLET	1-1/4 in. Ø FNPT
AIR EXHAUST NOZZLE	8 in. Ø STUB W/8x8 CPLG

NORTH EAST ENVIRONMENTAL PRODUCTS, INC.
17 TECHNOLOGY DRIVE
WEST LEBANON, NEW HAMPSHIRE 03784
PHONE: 603-298-7061 FAX: 603-298-7063

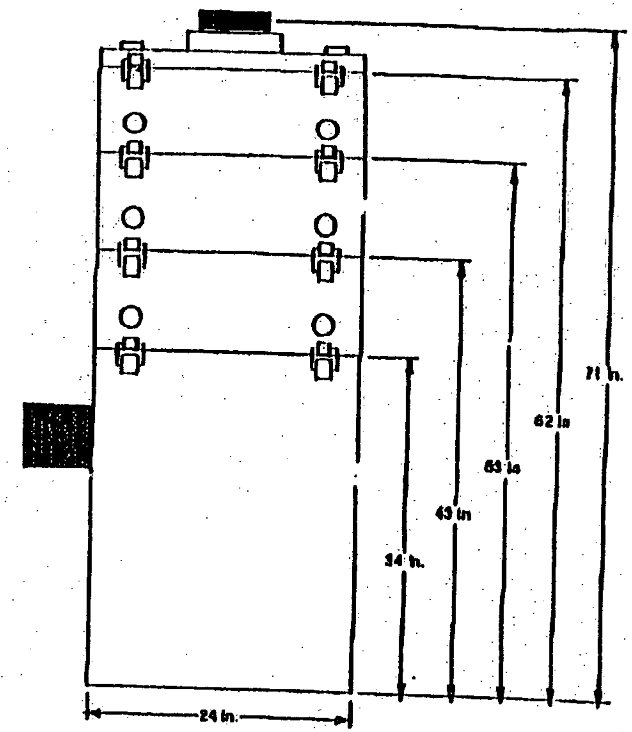
DRAWING NAME:	ShallowTray® Model 2330-P
DRAWING #:	Proposal #697906
DRAWN: DCS	CUSTOMER: Independent Equip: Forensic, USVI
DATE: 6/20/97	SCALE: NTS · SIZE: A · SHEET: 1 OF 1

MINIMUM CLEARANCE	
FRONT	1.5 ft.
TOP	12 in.
REAR	N/A
LEFT	3.5 ft.
RIGHT	1 ft.

FRONT



RIGHT SIDE



BASIC SYSTEM

- ✓ SUMP TANK
- ✓ STRIPPER TRAYS
- BLOWER
- ✓ MIST ELIMINATOR
- ✓ PIPING
- ✓ SPRAY NOZZLE
- ✓ WATER LEVEL SIGHT TUBE
- ✓ GASKETS
- ✓ LATCHES

OPTIONAL ITEMS

- ___ FRAME
- ___ AIR PRESSURE GAUGE
- ___ DISCHARGE PIPING
- ___ DISCHARGE PUMP
- ___ FEED PUMP
- ___ ADDITIONAL BLOWER
- ___ EXPLOSION PROOF MOTOR(S)
- ___ BLOWER START-STOP PANEL
- ___ CONTROL PANEL
- ___ MAIN DISCONNECT SWITCH
- ___ I.S. COMPONENTS REMOTE MOUNT
- ___ INTERMITTENT OPERATION
- ___ STROBE LIGHT
- ___ ALARM HORN
- ___ POWER LAPSE INDICATOR
- ___ LOW AIR PRESSURE ALARM SWITCH
- ✓ HIGH WATER LEVEL ALARM SWITCH
- ✓ DISCHARGE PUMP LEVEL SWITCH
- ___ WATER PRESSURE GAUGE(S)
- ___ DIGITAL WATER FLOW INDICATOR
- ___ AIR FLOW METER
- ___ TEMPERATURE GAUGE(S)
- ___ LINE SAMPLING PORTS
- ___ AIR BLOWER SILENCER
- ___ WASHER WAND
- ___ AUTO DIALER

NOTE:

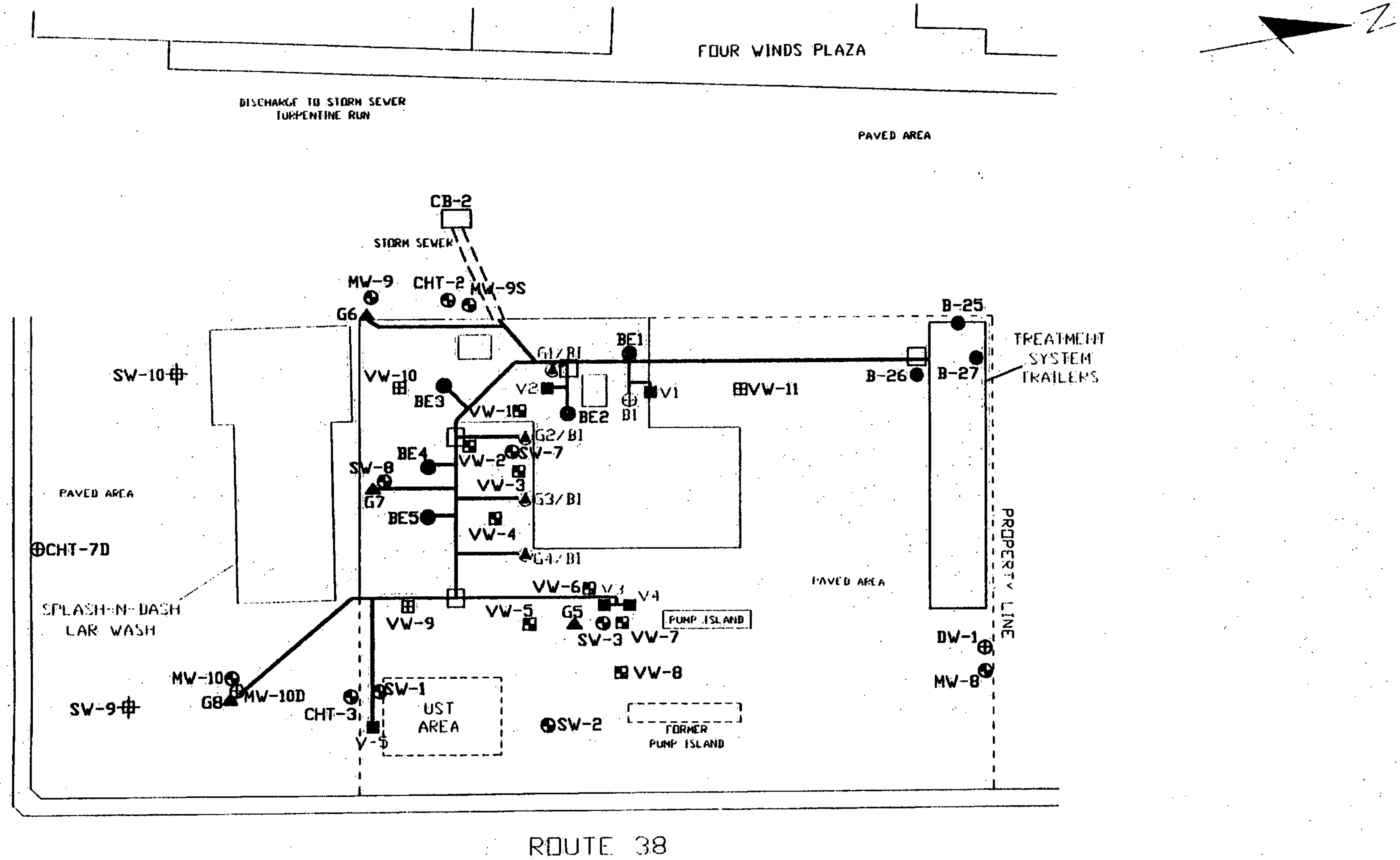
1. THIS DRAWING IS REPRESENTATIVE OF A TYPICAL CONFIGURATION SIMILAR TO THE UNIT REQUIRED, AND IS NOT INTENDED FOR ENGINEERING DESIGN OR LAYOUT. PLEASE CONTACT YOUR NEEP REPRESENTATIVE FOR DETAILED DESIGN INFORMATION

CONNECTION INFORMATION

ITEM	SIZE
GRAVITY DISCHARGE	3 in. Ø SOCKET, PVC 97
DISCHARGE PUMP	3/4 in. Ø FNPT
WATER INLET	2 in. Ø FNPT
AIR EXHAUST NOZZLE	6 in. Ø STUB w/6 in. CPLG

NORTH EAST ENVIRONMENTAL PRODUCTS, INC
17 TECHNOLOGY DRIVE
WEST LEBANON, NEW HAMPSHIRE 03784
PHONE: 603-298-7061 FAX: 603-298-7063

TOLERANCES UNLESS OTHERWISE METRIC ± 1.0MM in	DRAWING NAME: ShallowTray® Model 2330
	DRAWING #: Proposal # 607906
DRAWN: SAC	CUSTOMER: Independent Equip: Forensic, USVI
DATE: 6-20-97	SCALE: NTS · SIZE: A · SHEET 1 OF 1



LEGEND

VW-8	EXISTING VAPOR MONITORING POINT	V	VAPOR EXTRACTION WELL
VW-9	PROPOSED VAPOR MONITORING POINT	BI	BIOVENTING INJECTION WELL
SW-10	PROPSED MONITORING WELL LOCATION	BE	BIOVENTING EXTRACTION WELL
SW-1	EXISTING MONITORING WELL LOCATION	G8	GROUND-WATER EXTRACTION WELL
B-25	PROPOSED SOIL BORING LOCATION	G4/BI	GROUND-WATER EXTRACTION WELL CONVERTED TO BIOVENTING INJECTION WELL
			SYSTEM TRENCH

FORENSIC ENVIRONMENTAL SERVICES, INC.

FIGURE 1

SOIL AND GROUND-WATER REMEDIATION SYSTEM SCHEMATIC

ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.

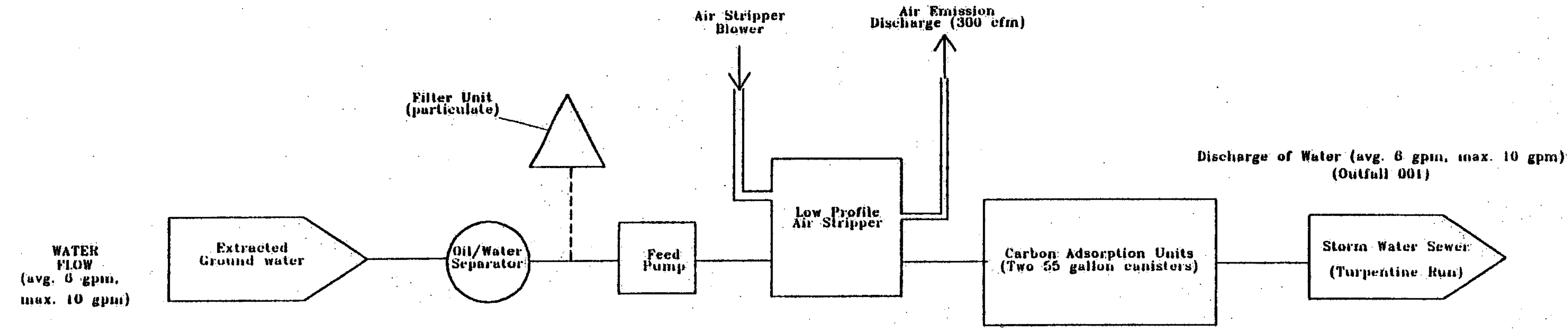
0 50
SCALE IN FEET

DRAWN BY: BJM 8/11/98

APPROVED BY

SOILGWPM.DWG

Esso Tutu Service Station
Air Pollution Control
Ground-Water Flow Diagram



Notes:

1. Influent water will be sourced from four ground-water extraction wells (four overburden, 4 shallow bedrock). It is anticipated that ground water will be extracted from each overburden well at an average rate of 0.5 gallons per minute (gpm), and from each shallow bedrock well at an average rate of 1.0 gpm, for a total average withdrawl of 6 gpm.
2. Discharge of vapors from the air stripper will occur at a rate of approximately 300 cubic feet per minute (cfm). The estimated concentration of total volatile organic compounds in the air stream is 0.078 pounds per hour at 6 gpm, and 0.130 pounds per hour at 10 gpm.

TUTULINE.DWG

GOVERNMENT OF
THE VIRGIN ISLANDS OF THE UNITED STATES
DEPARTMENT OF PLANNING AND NATURAL RESOURCES
AIR POLLUTION CONTROL

APPLICATION

AUTHORITY TO CONSTRUCT AND PERMIT TO OPERATE

INSTRUCTIONS

A. This application must be filled out completely and must be filed in TRIPLICATE.

B. Applications are incomplete unless accompanied by DUPLICATE copies of all plans, specifications and drawings required. Details required for specific equipment are listed on separate forms which are available upon request.

INCOMPLETE APPLICATIONS ARE NOT ACCEPTABLE

Date of Application: REVISED SEPT. 24, 1998

APPLICATION INFORMATION

1. Permit to be issued to: (Business License Name of Corporation, Company, Individual Owner or Governmental Agency that is to operate the Equipment):

ESSO VIRGIN ISLANDS, INC

2. Mailing Address:

P.O. Box ESSO TERMINAL City CHARLOTTE AMALIE Island ST. THOMAS Zip 00801

3. Address at which the equipment is to be operated:

Number 384 Street ESTATE ANNA'S RETREAT Island ST. THOMAS Zip 00802

4. Type of Organization: Corp. X Partnership ____ Individual Owner ____ Governmental Agency ____

5. General Nature of Business:

PETROLEUM RETAIL SERVICE STATION

6. Equipment Description: Pursuant to the Provisions of the U.S. Virgin Islands Code and the Rules and Regulations of the Air Pollution Control Region, application is hereby made for authority to construct and permit to operate the following equipment:

SOIL VAPOR EXTRACTION SYSTEM (ESSO TUTU SOIL REMEDIATION PROGRAM)

Sec. A	1. ☒ New process equipment and new air pollution control apparatus ☐ New air pollution control apparatus on existing process equipment ☐ New process equipment with no control apparatus ☐ Other: ______ 2. Prior permit numbers covering this installation. Specify. NOT APPLICABLE 3. Estimated starting date OCTOBER 1998 Est. completion 2002
Sec. B	1. Description of operation REMOVAL OF CONTAMINANTS FROM SUBSURFACE BY VACUUM EXTRACTION 2. Identify process equipment VACUUM BLOWER, CATALYTIC OXIDIZER 3. Raw materials (names) VAPORS FROM SOIL CONTAMINATED WITH PETROLEUM CONSTITUENTS AND CHLORINATED HYDROCARBONS Total pounds per hour 0.043 Total pounds per batch — SEE ATTACHED TABLES (1a AND 1b) 4. Operating procedure: ☒ Continuous: 24 hrs. per day 7 days per ☒ week ☐ month ☐ Batch: — hrs. per batch — batches per ☐ day ☐ week

Physical and chemical nature of air contaminants which must evolve from operation and be emitted into the open air:

Sec. C	Air Contaminants	Amounts of Contaminants: With Control Apparatus	Amounts of Contaminants: Without Control Apparatus
	(SEE ATTACHED TABLE 1C		
	FOR A COMPLETE LIST OF		
	AIR CONTAMINANTS)		

Sec. D	
	1. Describe air pollution control apparatus EXTRACTED SOIL VAPORS WILL BE PROCESSED THROUGH A MOISTURE KNOCK-OUT CANISTER, AN IN-LINE PARTICULATE FILTER, AND A CATALYTIC OXIDATION UNIT
	2. Efficiency of control apparatus: MINIMUM 95 %
	3. Height of discharge above ground 9.5 ft.
	4. Distance from discharge to nearest property line APPROX 15 ft.
	5. Volume of gas discharged into open air AVG. - 125 MAX. - 175 cu. ft. per min. at stack conditions.
	6. Exit linear velocity at point of discharge 560 ft. per min. at stack conditions.
	7. Temperature at point of discharge 600 °F.
	8. Will emissions comply with existing local requirements? YES
	9. Initial cost of control apparatus $ N/A
	10. Estimated annual operating cost $ 40,000

This application is submitted in accordance with the provisions of the Virgin Islands Code 12, Chapter 9, Air Quality Control Regulations Section 206-20, and to the best of my knowledge and belief is true and correct.

ESSO VIRGIN ISLANDS INC
CYRIL E. KING
AIRPORT TERMINAL

ST. THOMAS USVI
Mailing Address

00804
Zip Code

Signature - all copies

Name (print or type)

Title

Telephone No.

[illegible] CONSTRUCT AND [illegible]

[illegible] APPROVED

[illegible] Approved by

Permit No. [illegible] Supervisor, [illegible]

Esso Tutu Service Station
SVE System
Air Pollution Control Permit
Equipment Description

System Description

As part of the USEPA CERCLA Record of Decision, Esso Virgin Islands, Inc. is required to remediate subsurface soils beneath the Esso Tutu Service Station. The subject site is located on Route 38, Anna's Retreat, St. Thomas, adjacent to Four Winds Plaza (Figure 1).

The proposed soil remedial program will involve the extraction of soil vapors from five vapor extraction wells and five bioventing wells (Figure 1). Wells will be installed to a depth of approximately 15 feet and utilized to extract gases within the soil matrix at a flow rate of 15 to 20 cubic feet per minute (cfm) per vapor extraction well. Bioventing wells will be utilized to extract vapors at 3 to 5 cfm. Extracted soil vapors will be transferred to an on-site treatment building through two manifold systems (SVE and bioventing), as shown in Figure 1. The process flow of the extracted vapors in the treatment building will include the following components:

1. Moisture knockout tank,
2. Filter apparatus (particulate),
3. Vacuum blower, and
4. Catalytic oxidizer (Cat-ox)

The above components will operate in conjunction as the Control Apparatus for the soil vapor extraction remedial system. The treatment system has been designed to reduce contaminant concentrations in the vapor effluent to 0.0428 lbs/hour (see Tables 1a, 1b, and 1c). Treated soil vapors will be discharged to the atmosphere via the insulated cat-ox stack. The above components are illustrated in attached "Soil Vapor Flow Diagram" and "Process & Instrumentation Diagram".

Equipment Description

Air emissions associated with the soil vapor remediation system will occur only after treatment by catalytic oxidation. All components upstream of the cat-ox unit are air-tight and will not produce any emissions. The selected vacuum blower is a Rotron-brand, Model EN/CP6 Regenerative Blower, capable of generating an air flow rate of 175 cfm at 20 inches of water column. The cat-ox unit (ThermTech Model #VAC-25) is capable of processing air flows up to 225 cfm.

Off-gas concentrations will be monitored during operation of the remedial system to ensure that effluent concentrations do not exceed those predicted. Compliance monitoring will include both vapor measurements using a Photoionization Detector (PID) and the collection of vapor samples for analytical testing. A schedule for compliance monitoring for the first 12 months is provided on Table 1d. DPNR will be copied on all air emission monitoring data.

The mass of VOC compounds removed by the SVE system are expected to decrease over time and eventually level off. It is anticipated that DPNR will establish a de minimus cut-off value for the influent monitoring, at which, the SVE treatment system will no longer require control apparatus. At this point, untreated effluent from the SVE/Bioventing system would be discharged directly to the atmosphere, with de minimus quantities of VOCs released.

Table 1a
Air Emissions Calculations (Average System Discharge)
SVE System (Catalytic Oxidizer Effluent)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Compound	Average Soil Vapor Concentration		Molecular Weight	Average Contaminant Mass Per Well				Contaminant Mass All Wells @ 125 cfm		Contaminant Mass All Wells @ 175 cfm	
	ppbv	ppmv	gm/mole	mg/m^3	kg/m^3	kg/ft^3	lbs/ft^3	lbs/cfm	$lbs/ft^3/hour$	lbs/cfm	$lbs/ft^3/hour$
Pentane	123200	123.200	72.2	363.805	3.64E-04	1.03E-05	2.27E-05	0.0028	0.170	0.0040	0.239
Hexane	9300	9.300	86.2	32.788	3.28E-05	9.29E-07	2.05E-06	0.0003	0.015	0.0004	0.021
Heptane	74	0.074	100.2	0.303	3.03E-07	8.59E-09	1.89E-08	2.37E-06	1.42E-04	3.31E-06	1.99E-04
Isooctane	4530	4.530	114.2	21.159	2.12E-05	5.99E-07	1.32E-06	0.0002	0.010	0.0002	0.014
Octane	434	0.434	114.2	2.027	2.03E-06	5.74E-08	1.27E-07	1.58E-05	0.001	2.21E-05	0.001
Benzene	1910	1.910	78.1	6.101	6.10E-06	1.73E-07	3.81E-07	4.76E-05	0.003	6.67E-05	0.004
MTBE	7	0.007	88.2	0.025	2.52E-08	7.15E-10	1.58E-09	1.97E-07	1.18E-05	2.76E-07	1.65E-05
Toluene	316	0.316	92.1	1.190	1.19E-06	3.37E-08	7.43E-08	9.29E-06	0.001	1.30E-05	0.001
Ethylbenzene	4026	4.026	106.2	17.487	1.75E-05	4.95E-07	1.09E-06	0.0001	0.008	0.0002	0.011
m- & p- Xylenes	372	0.372	106.2	1.616	1.62E-06	4.58E-08	1.01E-07	1.26E-05	0.001	1.77E-05	0.001
o-Xylenes	104	0.104	106.2	0.452	4.52E-07	1.28E-08	2.82E-08	3.53E-06	2.12E-04	4.94E-06	2.96E-04
4-Ethyltoluene	256	0.256	120.2	1.259	1.26E-06	3.56E-08	7.86E-08	9.82E-06	0.001	1.38E-05	0.001
Cumene	1453	1.453	120.2	7.143	7.14E-06	2.02E-07	4.46E-07	0.0001	0.003	7.80E-05	0.005
1,2,4 Trimethylbenzene	406	0.406	120.2	1.996	2.00E-06	5.65E-08	1.25E-07	1.56E-05	9.35E-04	2.18E-05	1.31E-03
1,3,5 Trimethylbenzene	142	0.142	120.2	0.698	6.98E-07	1.98E-08	4.36E-08	5.45E-06	3.27E-04	7.63E-06	4.58E-04
Carbon Disulfide	19	0.019	76.1	0.059	5.91E-08	1.67E-09	3.69E-09	4.62E-07	2.77E-05	6.46E-07	3.88E-05
Freon 113	19	0.019	187.4	0.146	1.46E-07	4.12E-09	9.09E-09	1.14E-06	6.82E-05	1.59E-06	9.55E-05
Trichloroethene	18	0.018	131.4	0.097	9.67E-08	2.74E-09	6.04E-09	7.55E-07	4.53E-05	1.06E-06	6.34E-05
Tetrachloroethane	101	0.101	165.8	0.685	6.85E-07	1.94E-08	4.28E-08	5.35E-06	3.21E-04	7.48E-06	4.49E-04
TICs/C_3-C_4	12107	12.107	86.2	42.684	4.27E-05	1.21E-06	2.67E-06	0.0003	0.020	0.0005	0.028
TICs/C_5-C_{10}	9990	9.990	184.4	75.344	7.53E-05	2.13E-06	4.70E-06	5.88E-04	0.035	0.0008	0.049
	A	B = A/1000	C	D = BxC/24.45	E = D/1000000	F = E/35.31	G = Fx2.20	H = Gx125	I = Hx60	H = Gx125	I = Hx60

Total vapor contaminant mass removed by treatment system in pounds/hour =	0.270	0.378
Total estimated air emission in pounds/hour (assumes minimum cat-ox destruction efficiency of 95%) =	**0.014**	**0.019**

ppbv = parts per billion by volume, ppmv = parts per million by volume, mg = milligrams, gm = grams,
kg = kilograms, lbs = pounds, m^3 = cubic meters, ft^3 = cubic feet, cfm = cubic feet per minute
TICs = tentatively identified compounds. For estimation purposes, the TIC with the highest molecular weight in each group (2,2-dimethylbutane, 2,3,4,-trimethyldecane) was used in the calculations.
Average soil vapor concentrations based on quantitative vapor samples collected at the site in September/October 1996.
Total estimated air flow from all wells is estimated at 125 cfm. Catalytic oxidizer will provide at least 95% treatment efficiency.

Table 1b
Air Emissions Calculations (Maximum System Discharge)
SVE System (Catalytic Oxidizer Effluent)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Compound	Maximum Soil Vapor Concentration		Molecular Weight	Average Contaminant Mass Per Well				Contaminant Mass All Wells @ 125 cfm		Contaminant Mass All Wells @ 175 cfm	
	ppbv	ppmv	gm/mole	mg/m^3	kg/m^3	kg/ft^3	lbs/ft^3	lbs/cfm	lbs/ft^3/hour	lbs/cfm	lbs/ft^3/hour
Pentane	260000	260.000	72.2	767.771	7.68E-04	2.17E-05	4.79E-05	0.0060	0.360	0.0084	0.503
Hexane	19000	19.000	86.2	66.986	6.70E-05	1.90E-06	4.18E-06	0.0005	0.031	0.0007	0.044
Heptane	200	0.200	100.2	0.820	8.20E-07	2.32E-08	5.12E-08	6.40E-06	3.84E-04	8.96E-06	5.37E-04
Isooctane	9200	9.200	114.2	42.971	4.30E-05	1.22E-06	2.68E-06	0.0003	0.020	0.0005	0.028
Octane	1300	1.300	114.2	6.072	6.07E-06	1.72E-07	3.79E-07	4.74E-05	0.003	0.0001	0.004
Benzene	5500	5.500	78.1	17.569	1.76E-05	4.98E-07	1.10E-06	0.0001	0.008	0.0002	0.012
MTBE	20	0.020	88.2	0.072	7.21E-08	2.04E-09	4.50E-09	5.63E-07	3.38E-05	7.88E-07	4.73E-05
Toluene	920	0.920	92.1	3.466	3.47E-06	9.81E-08	2.16E-07	2.70E-05	0.002	3.79E-05	0.002
Ethylbenzene	12000	12.000	106.2	52.123	5.21E-05	1.48E-06	3.25E-06	0.0004	0.024	0.0006	0.034
m- & p- Xylenes	1100	1.100	106.2	4.778	4.78E-06	1.35E-07	2.98E-07	3.73E-05	0.002	0.0001	0.003
o-Xylenes	300	0.300	106.2	1.303	1.30E-06	3.69E-08	8.14E-08	1.02E-05	6.10E-04	1.42E-05	8.54E-04
4-Ethyltoluene	760	0.760	120.2	3.736	3.74E-06	1.06E-07	2.33E-07	2.92E-05	0.002	4.08E-05	0.002
Cumene	4300	4.300	120.2	21.139	2.11E-05	5.99E-07	1.32E-06	0.0002	0.010	0.0002	0.014
1,2,4 Trimethylbenzene	1200	1.200	120.2	5.899	5.90E-06	1.67E-07	3.68E-07	4.60E-05	0.003	0.0001	0.004
1,3,5 Trimethylbenzene	420	0.420	120.2	2.065	2.06E-06	5.85E-08	1.29E-07	1.61E-05	9.67E-04	2.26E-05	0.001
Carbon Disulfide	50	0.050	76.1	0.156	1.56E-07	4.41E-09	9.72E-09	1.21E-06	7.29E-05	1.70E-06	1.02E-04
Freon 113	50	0.050	187.4	0.383	3.83E-07	1.09E-08	2.39E-08	2.99E-06	1.79E-04	4.19E-06	2.51E-04
Trichloroethene	29	0.029	131.4	0.156	1.56E-07	4.41E-09	9.73E-09	1.22E-06	7.30E-05	1.70E-06	1.02E-04
Tetrachloroethane	230	0.230	165.8	1.560	1.56E-06	4.42E-08	9.74E-08	1.22E-05	7.30E-04	1.70E-05	0.001
TICs/C_3-C_4	31500	31.500	86.2	111.055	1.11E-04	3.15E-06	6.93E-06	0.0009	0.052	0.0012	0.073
TICs/C_5-C_{10}	26000	26.000	184.4	196.090	1.96E-04	5.55E-06	1.22E-05	0.0015	0.092	2.14E-03	0.129
	A	B = A/1000	C	D = BxC/24.45	E = D/1000000	F = E/35.31	G = Fx2.20	H = Gx125	I = Hx60	H = Gx125	I = Hx60

Total vapor contaminant mass removed by treatment system in pounds/hour =	0.612		0.856
Total estimated air emission in pounds/hour (assumes minimum cat-ox destruction efficiency of 95%) =	**0.031**		**0.043**

ppbv = parts per billion by volume, ppmv = parts per million by volume, mg = milligrams, gm = grams,
kg = kilograms, lbs = pounds, m^3 = cubic meters, ft^3 = cubic feet, cfm = cubic feet per minute
TICs = tentatively identified compounds. For estimation purposes, the TIC with the highest molecular weight in each group (2,2-dimethylbutane, 2,3,4,-trimethyldecane) was used in the calculations.
Maximum soil vapor concentrations based on quantitative vapor samples collected at the site in September/October 1996.
Total estimated air flow from all wells is estimated at 125 cfm. Catalytic oxidizer will provide at least 95% treatment efficiency.

Table 1c
Air Emissions Calculations
SVE/Bioventing System
Esso Tutu Service Station
St. Thomas, U.S.V.I.

SECTION C				
Air Contaminants	**Amounts of Contaminants**			
	Without Control Apparatus (lbs/hr)		**With Control Apparatus (lbs/hr)**	
	125 cfm	**175 cfm**	**125 cfm**	**175 cfm**
Pentane	0.3595	0.5033	0.0180	0.0252
Hexane	0.0314	0.0439	0.0016	0.0022
Heptane	0.0004	0.0005	1.92E-05	2.69E-05
Isooctane	0.0201	0.0282	0.0010	0.0014
Octane	0.0028	0.0040	0.0001	0.0002
Benzene	0.0082	0.0115	0.0004	0.0006
MTBE	3.38E-05	4.73E-05	1.69E-06	2.36E-06
Toluene	0.0016	0.0023	0.0001	0.0001
Ethylbenzene	0.0244	0.0342	0.0012	0.0017
m- & p- Xylenes	0.0022	0.0031	0.0001	0.0002
o-Xylenes	0.0006	0.0009	3.05E-05	4.27E-05
4-Ethyltoluene	0.0017	0.0024	0.0001	0.0001
Cumene	0.0099	0.0139	0.0005	0.0007
1,2,4 Trimethylbenzene	0.0028	0.0039	0.0001	0.0002
1,3,5 Trimethylbenzene	0.0010	0.0014	0.0000	0.0001
Carbon Disulfide	0.0001	0.0001	3.64E-06	5.10E-06
Freon 113	0.0002	0.0003	8.97E-06	1.26E-05
Trichloroethene	0.0001	0.0001	3.65E-06	5.11E-06
Tetrachloroethane	0.0007	0.0010	3.65E-05	0.0001
TICs/C_3-C_4	0.0520	0.0728	0.0026	0.0036
TICs/C_5-C_{10}	0.0918	0.1286	0.0046	0.0064
TOTAL	0.6116	0.8563	0.0306	0.0428

Assumptions used to estimate discharge in pounds per hour (lbs/hr)
are identified in Table 1b (maximum concentrations).
Average operational system flow rate is estimated at 125 cubic feet per minute (cfm);
maximum estimated system flow rate is 175 cfm

Table 1d
Schedule of Compliance Monitoring
SVE System (Catalytic Oxidizer Effluent)
Air Pollution Control Permit
Esso Tutu Service Station
St. Thomas, U.S.V.I.

	Sampling Frequency	
Time From System Start-up	**Qualitative Sampling (PID)**	**Quantitative Sampling (Laboratory)**
0 - 2 weeks	Four times per week; influent and effluent	Twice per week; influent and effluent for VOCs via TO-14
2 weeks - 8 weeks	Twice per week; influent and effluent	Twice per month; influent and effluent for VOCs via TO-14
2 - 6 months	Once per week; influent and effluent	Monthly; influent and effluent for VOCs via TO-14
6 - 12 months	Once per month; influent and effluent	Monthly; influent and effluent for VOCs via TO-14

influent = pre-catalytic oxidizer vapor sample; effluent = catalytic oxidizer vapor discharge sample

February 1, 1994

VAPOR CHECK

MODEL: VAC 25

GENERAL DATA

* SCFM rating	250 SCFM (7.1 m³/min)
* burners maximum output capability	1,000,000 BTU/Hr
* burner turndown ratio	20 to 1
* combustion blower motor size	1 HP (0.75 KW)
* combustion chamber I D	27" x 27" x 60" (68.6cm x 68.6cm x 152.4cm)
* stack I D	12" x 12" (30.5cm x 30.5cm)
* skid size.	38" x 123" (99cm x 304.8cm)
* velocity through 4" process inlet	
@ 125 SCFM (3.5 m³/min) from process stream	23.8 ft/sec (7.25 m/sec)
@ 250 SCFM (7.1 m³/min) from process stream	47.5 ft/sec (14.48 m/sec)

THERMAL DATA

* SCFM added by combustion blower when fired on ratio	95 SCFM (2.7 m³/min)
* total ACFM @ 1400°F (760°C)	1219 ACFM (34.5 m³/min)
* burner chamber volume required for 0.5 seconds retention time @ 1400°F (760°C)	10.2 ft³ (0.289 m³)
* burner chamber volume required for 1.0 seconds retention time @ 1500°F (815°C)	21.4 ft³ (0.606 m³)
* stack velocity @ 1400°F (760°C)	
@ 125 SCFM (3.5 m³/min) from process stream	10.2 ft/sec (3.11 m/sec)
@ 250 SCFM (7.1 m³/min) from process stream	20.3 ft/sec (6.19 m/sec)
* estimated weight, thermal unit only	2050 lbs (703 Kg)

CATALYTIC DATA

* SCFM added by combustion blower when fired on ratio	29 SCFM (0.82 m³/min)
* total ACFM @ 600°F (315°C)	560 ACFM (15.6 m³/min)
* catalyst volume for 95% plus destructive efficiency	0.54 ft³ (15,291 cm³)
* inlet temperature	600°F (315°C)
* maximum concentrations	25% of the LEL
* stack velocity @ 600°F (315°C)	
@ 125 SCFM (3.5 m³/min) from process stream	4.7 ft/sec (1.43 m/sec)
@ 250 SCFM (7.1 m³/min) from process stream	9.3 ft/sec (2.84 m/sec)
* estimated weight, thermal unit plus catalytic module (95% destruction)	2175 (903 Kg)

* The above data is intended to be used as general, guide line type information. For specific application proposal, please contact the manufacturer.

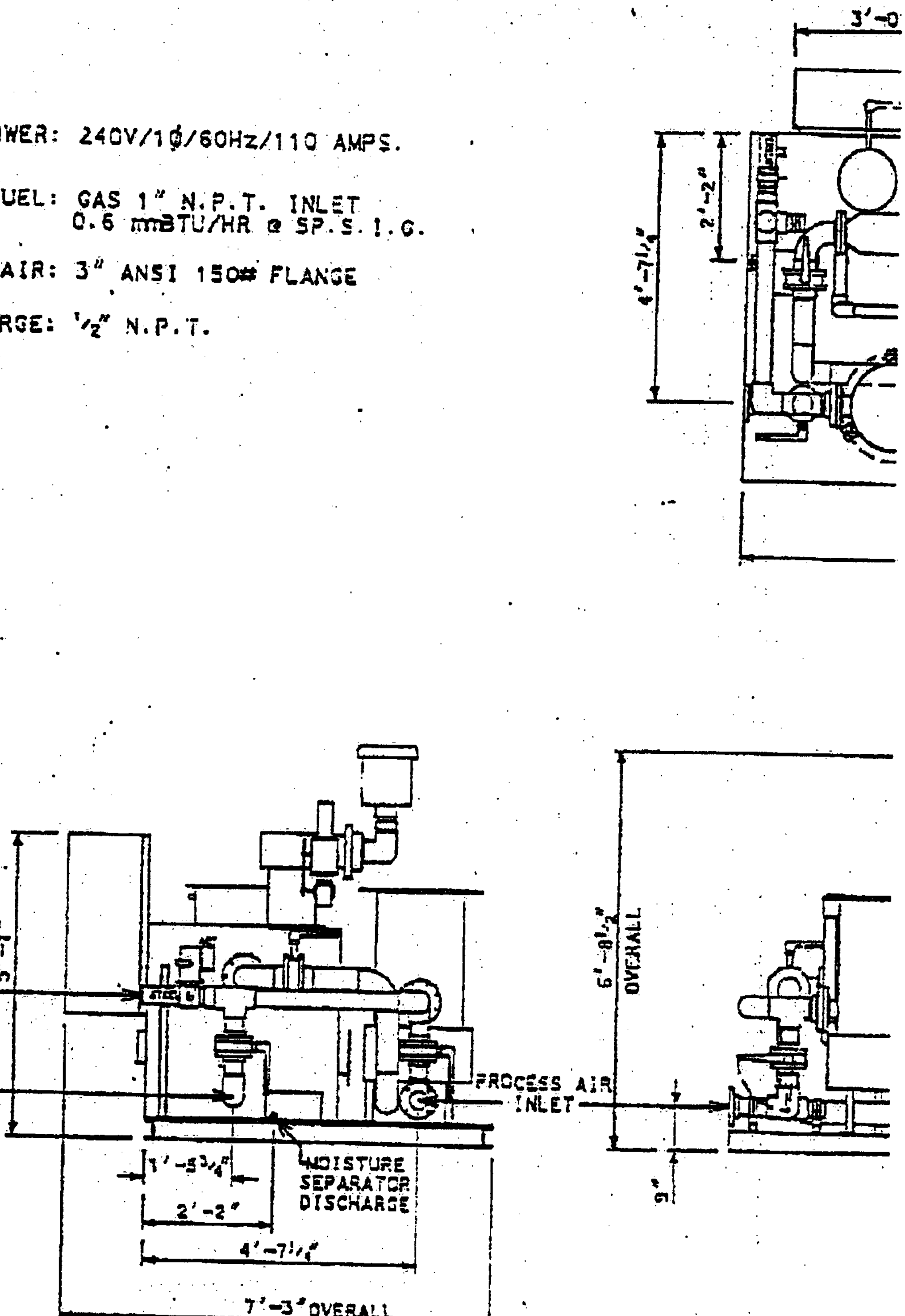
SPECIFICATIONS:

POWER: 240V/1Ø/60Hz/110 AMPS.

PURCHASED FUEL: GAS 1" N.P.T. INLET
0.6 mmBTU/HR @ 5P.S.I.G.

PROCESS AIR: 3" ANSI 150# FLANGE

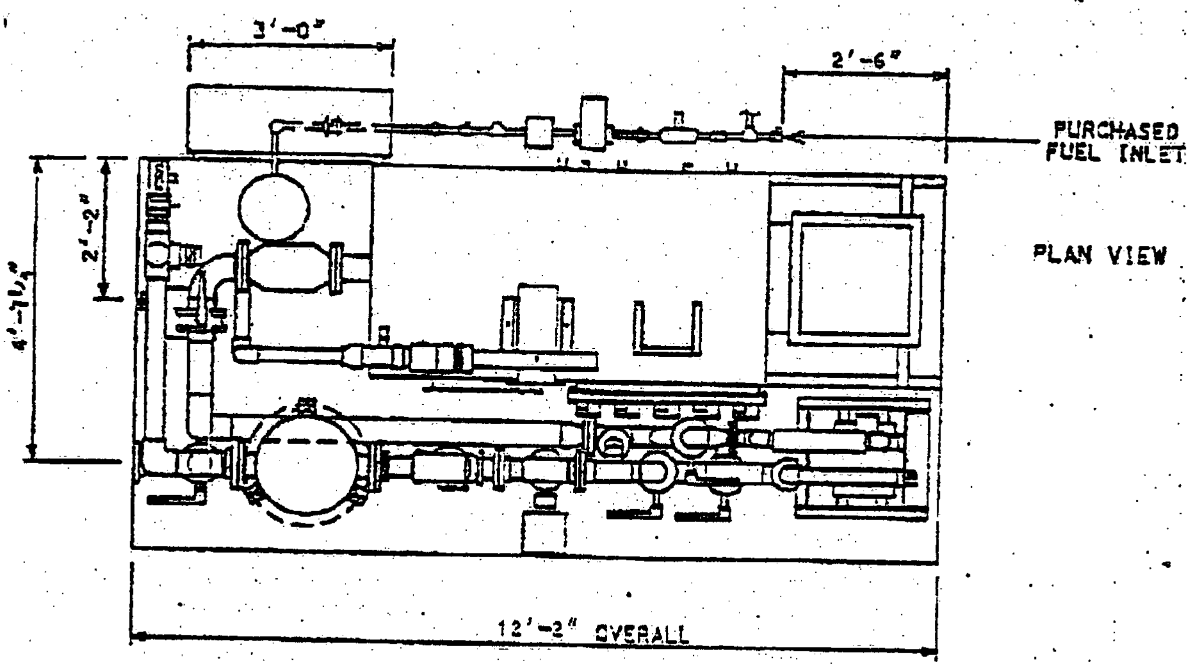
MOISTURE SEPARATOR DISCHARGE: ½" N.P.T.



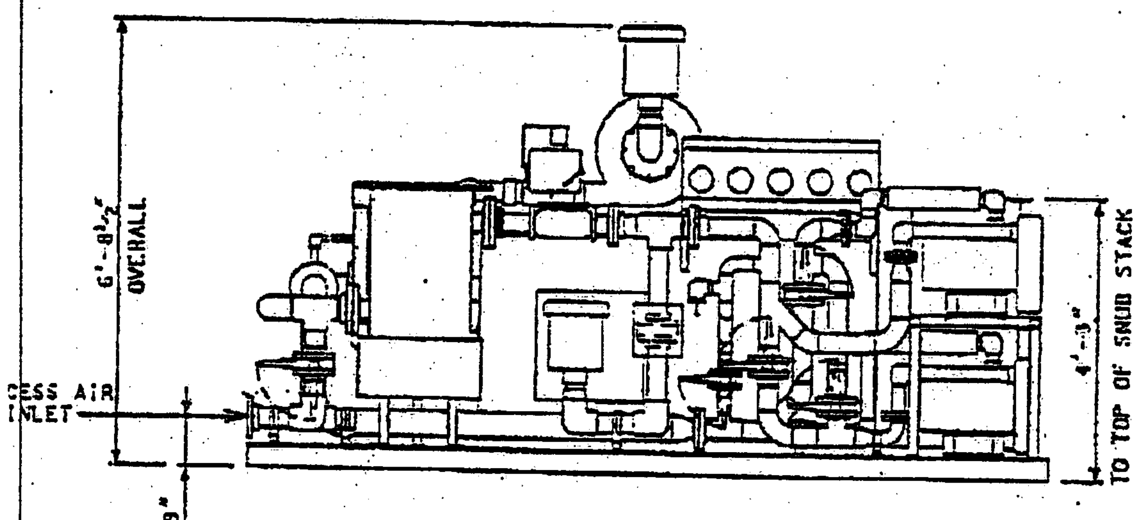
BURNER END VIEW

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

NO.	DATE	REV



PLAN VIEW



MANWAY SIDE VIEW

THERMTECH, INC.
THERMAL/CATALYTIC OXIDIZERS
KINGWOOD, TEXAS 1-800-659-8271

VAC 25 SKID MOUNTED

DRAWN	DATE	SCALE	JOB	PAGE
LZ	3/18/94	N.T.S.	N/A	1 OF 1
CHK'D	DATE			
APP'D	DATE			

CATALYTIC

The **VAPOR CHECK** catalytic module when added to your **VAPOR CHECK** thermal oxidizer converts your thermal oxidizer to a catalytic oxidizer. This system has been designed to be as energy efficient as possible while still offering the destructive efficiency necessary to meet and/or exceed EPA and your local air quality control standards.

While the catalytic mode of operation has the distinct advantage of using less fuel than it's thermal sister it also has some inherent disadvantages. Catalyst of all types, can be deactivated by lead, sulfur, chlorinated hydrocarbons, silicon and phosphorus containing compounds. The result of this deactivation is reduction of destructive efficiency. In addition to those compounds mentioned, all particulates may also cover catalyst surfaces, thereby reducing activity by this masking effect. While trace amounts of the above agents may not lower the catalyst activity or shorten it's life, appreciable quantities must not be present in the gas stream. Check with Factory for written recommendations specifically addressing your process stream.

Our catalyst is an extremely active precious metal catalyst having a lower temperature limit of 500°F (260°C) and an upper temperature limit of 1350°F (732°C). Generally, in a field catalytic oxidizer such as the **VAPOR CHECK** system, you will find a 25°F (13.8°C) increase in the catalyst bed temperature for each 1.0% of the LEL of hydrocarbon passing through the bed. For specific application information, please supply us with the exact chemical analysis.

The destructive efficiency of your catalytic system is directly related to the catalytic bed temperature, the quantity of catalyst in the bed, and the actual condition of the catalyst. Typically, the destructive efficiency of this catalytic system can be improved by increasing either/or both the amount of catalyst and /or the bed's inlet temperature while observing the exit temperature to be sure you do not exceed the catalyst's upper temperature limit of operation. This is an important fact about the operation of a catalytic oxidizer. If the catalyst is in good condition (has not been deactivated), the difference between 50% destructive efficiency and 99% destructive efficiency is directly related to the amount of catalyst in the bed and the temperature of that bed.

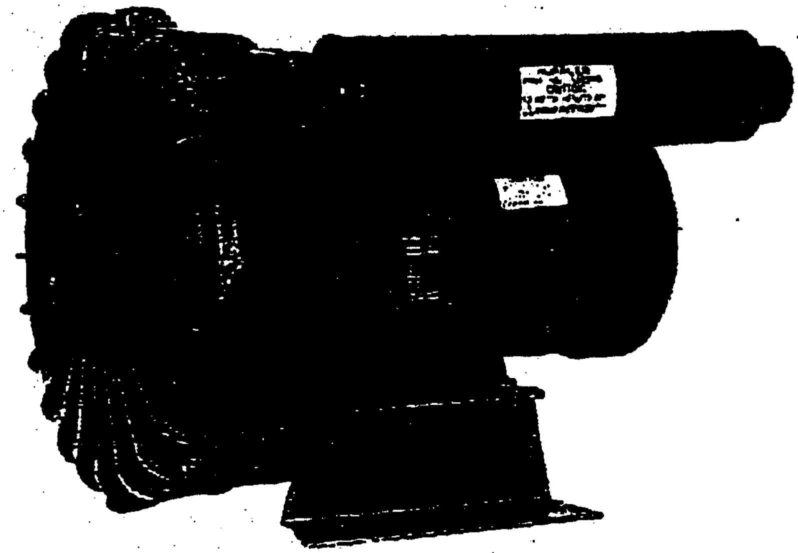
EG&G ROTRON

EN/CP 6
Explosion-Proof Regenerative Blower

EN FEATURES
- Manufactured in the USA
- Maximum flow: 225 SCFM
- Maximum pressure: 104" WG
- Maximum vacuum: 85" WG
- Standard motor: 5.0 HP
- Blower construction – cast aluminum housing, cover, impeller & manifold; cast iron flanges
- UL & CSA approved motors for Class I, Group D atmospheres
- Sealed blower assembly
- Quiet operation within OSHA standards

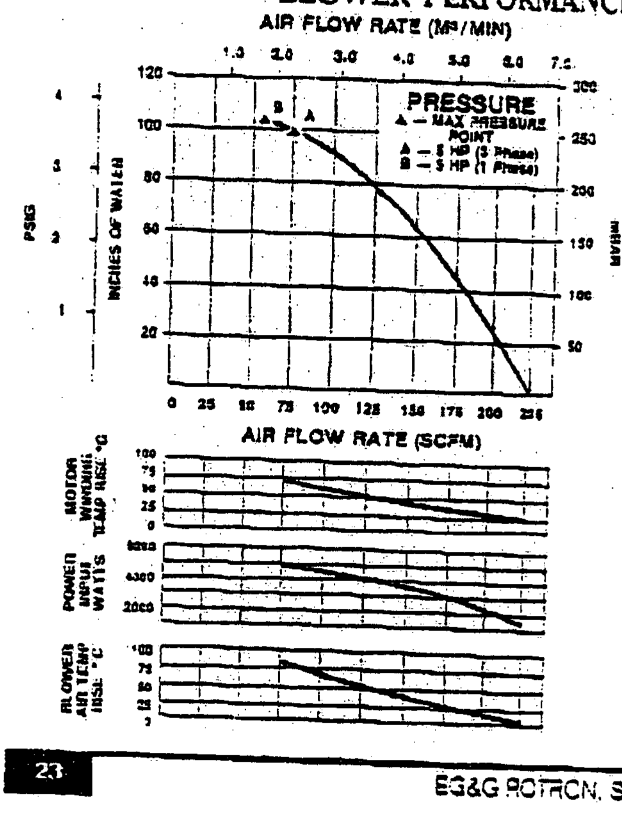
OPTIONS
- TEFC motors
- 50 Hz motors
- International voltages
- Other HP motors
- Corrosion resistant surface treatments
- Remote drive (motorless) models

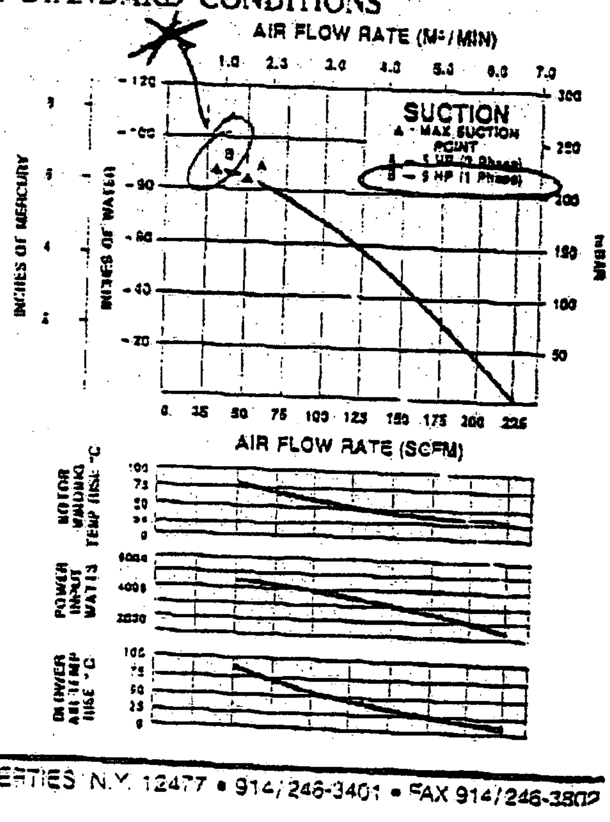
ACCESSORIES
- Moisture separators
- Explosion-proof motor starters
- Inline & inlet filters
- Vacuum & pressure gauges
- Relief valves
- External mufflers



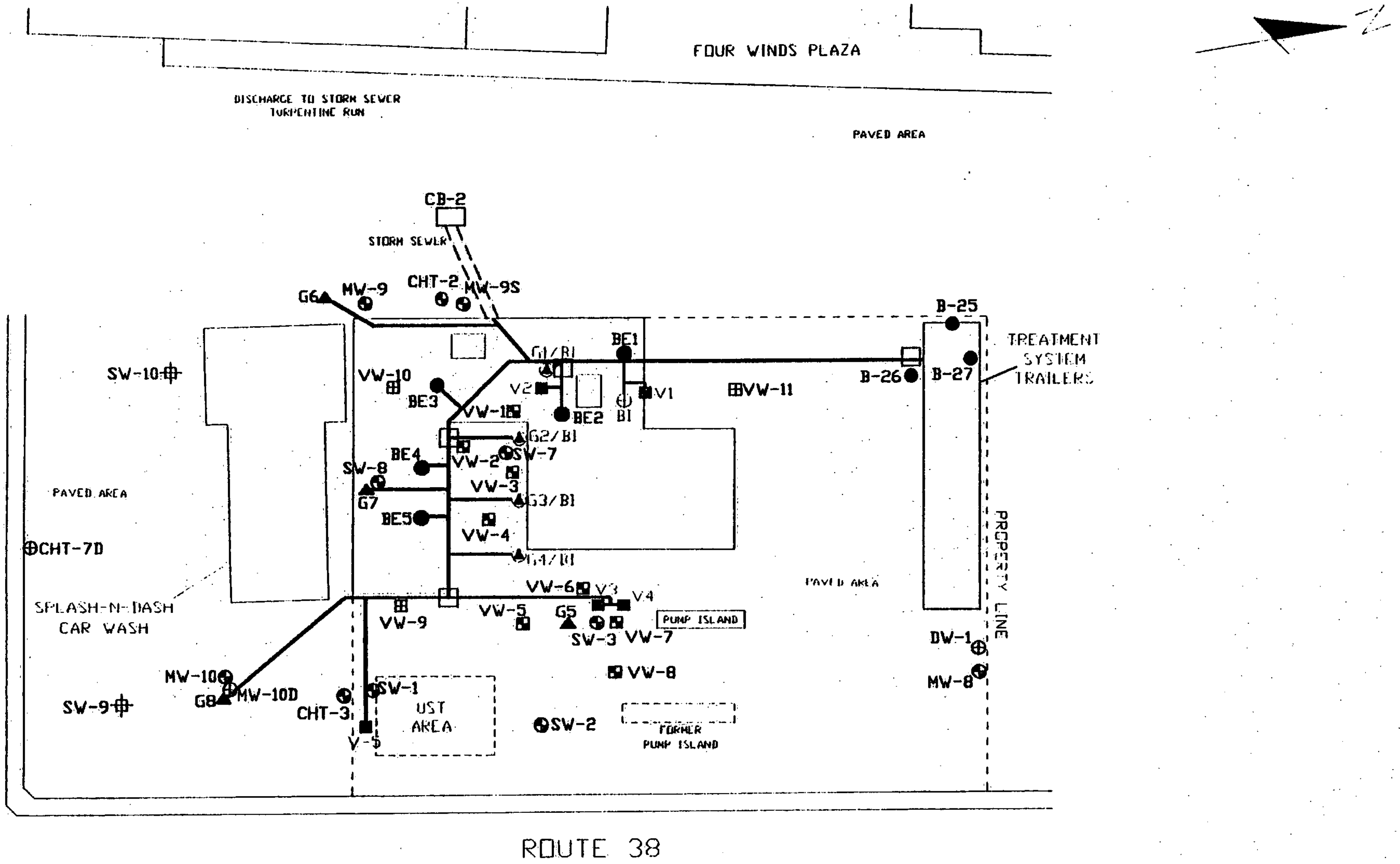
Blowers on Exxon Skid
w/ oxidizer

BLOWER PERFORMANCE AT STANDARD CONDITIONS





EG&G ROTRON, SAUGERTIES, N.Y. 12477 • 914/246-3401 • FAX 914/246-3802



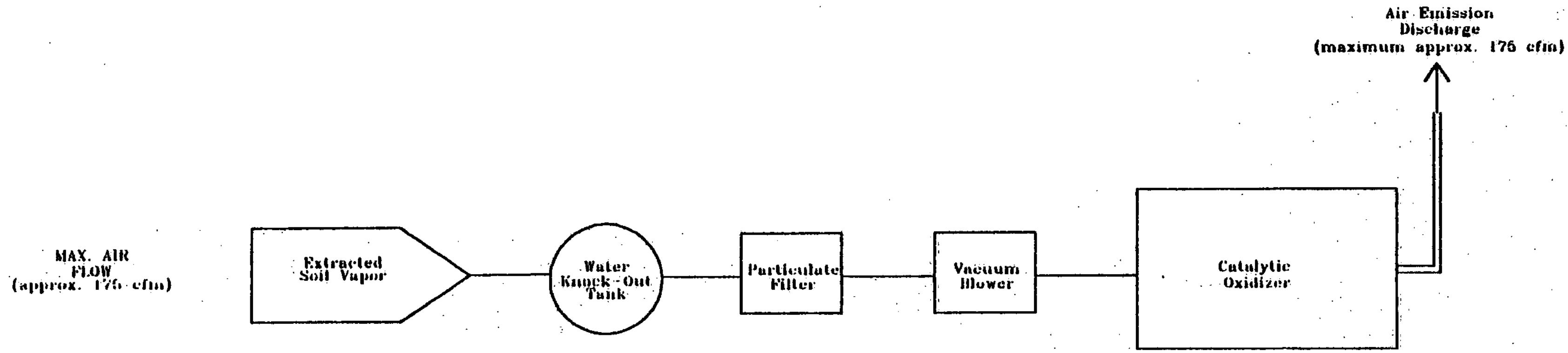
LEGEND

VW-8 EXISTING VAPOR MONITORING POINT	V VAPOR EXTRACTION WELL
VW-9 PROPOSED VAPOR MONITORING POINT	BI BIOVENTING INJECTION WELL
SW-10 PROPSED MONITORING WELL LOCATION	BE BIOVENTING EXTRACTION WELL
SW-1 EXISTING MONITORING WELL LOCATION	G8 GROUND WATER EXTRACTION WELL
B-25 PROPOSED SOIL BORING LOCATION	G4/BI GROUND WATER EXTRACTION WELL CONVERTED TO BIOVENTING INJECTION WELL
	SYSTEM TRENCH

FORENSIC ENVIRONMENTAL SERVICES, INC.	FIGURE 1
SOIL AND GROUND-WATER REMEDIATION SYSTEM SCHEMATIC ESSO TUTU SERVICE STATION ST. THOMAS, U.S.V.I.	
0 50 SCALE IN FEET	DRAWN BY BJM 8/11/98 APPROVED BY

SOILGWPM.DWG

Esso Tutu Service Station
Air Pollution Control
Soil Vapor Flow Diagram



Notes:

1. Influent soil vapors will be sourced from five soil vapor extraction wells and five bioventing wells. It is anticipated that soil vapors will be extracted from vapor extraction wells at an average rate of 20 cubic feet per minute (cfm), and from bioventing wells at an average rate of 5 cfm, for a total average extraction rate of approx. 125 cfm and a maximum rate of 175 cfm.

2. Influent soil vapor will be treated by a catalytic oxidation unit. The estimated maximum concentration of total volatile organic compounds in the effluent air stream is 0.019 pounds per hour (assuming a 95% removal efficiency by catalytic oxidation).

3. All soil vapor extracted from the wells will be treated and discharged: influent volume is equivalent to effluent volume.

SVEFLOW.DWG

Forensic Environmental Services, Inc.
113 John Robert Thomas Drive
The Commons at Lincoln Center
Exton, Pennsylvania 19341

Telephone: (610) 594-3940 Telecopier: (610) 594-3943

FAX AND MAIL

October 19, 1998

Mr. Leonard Reed
Assistant Director
Department of Environmental Protection
DPNR/DEP
Wheatley Center II
St. Thomas, USVI 00802

Re: Soil Vapor Extraction Unit (A/C), Ground-Water Air Stripper (A/C)
"Authority to Construct" Permit Nos. STT-755-A-98 and STT-755-B-98
Esso Tutu Service Station Remedial System

Dear Mr. Reed:

This correspondence serves to memorialize our telephone conversation of October 19, 1998 regarding the "Authority to Construct" Soil Vapor Extraction System and Ground-Water Air Stripper Air Pollution Control Permits issued on July 15, 1998 by the USVI Department of Planning and Natural Resources (DPNR) for the referenced site. The purpose of the telephone call was to determine the status of permit revisions submitted to DPNR on September 24, 1998 by Forensic Environmental Services, Inc. (FES), on behalf of Esso Virgin Islands, Inc. (Esso).

The permit revisions were necessary as a result of changes to the remedial system design/capacity which were made following discussions between the U.S. EPA, DPNR, Esso, and FES. These discussions, and the subsequent remedial system changes, occurred after submission of the original permit applications on September 25, 1997. To avoid possible delays in the remedial system construction schedule, FES requested that DPNR process the permit revisions within five business days.

During the October 19, 1998 telephone call, it was understood that unless there is a change of schedule, DPNR will begin review of the revised permit applications in November 1998. To avoid possible delays in remedial system construction, it was mutually agreed that FES/Esso may initiate installation of the Esso Tutu remedial system on November 2, 1998 pending receipt of the revised permits from DPNR.

FES greatly appreciates the understanding and cooperation of DPNR on this matter. If you do not feel the information provided herein is accurate, please call us immediately at 610-594-3940. If the information contained herein is accurate and acceptable, we would greatly appreciate receiving an acknowledgment (an initialed fax copy or similar) at your earliest convenience.

Sincerely,

FORENSIC ENVIRONMENTAL SERVICES, INC.

Robert W. Zei
Senior Hydrogeologist

Nicholas J. DeSalvo
Senior Project Manager

cc: Carlos Figueroa, Esso Standard Oil Company (Puerto Rico)
Chad Stevens, Esso Virgin Islands, Inc.

Agreed upon: Leonard Reed 22 X 98

APPENDIX C
Access Agreements

SITE ACCESS AGREEMENT

THIS AGREEMENT is made this ______ day of August, 1998, by and between Esso Virgin Islands Inc. ("ESSOVI") and Four Winds Plaza Partnership ("Four Winds")as the owner/landlord of certain property located on Route 38 in Estate Anna's Retreat ("the Site") and Splash and Dash, Inc. ("Splash and Dash") as the operator/tenant of certain property located on the Site.

WHEREAS, ESSOVI, through its contractors and subcontractors, and in accordance with EPA's Record of Decision (1996), and Unilateral Administrative Order (1998), and further pursuant to a certain remediation and indemnity agreement dated April 27, 1994, between, inter alia, ESSOVI and Four Winds ("the remediation agreement") wishes to install, operate and maintain components of the EPA's specified Source Control Program on the Site ("Site Work") (the specifics of which Site Work are set forth in Attachment "A" hereto).

WHEREAS, Four Winds has agreed to permit ESSOVI, or its contractors and subcontractors to enter upon the Four Winds property for the purpose of conducting such Site Work, pursuant to the remediation agreement and such other consideration as is set forth herein.

NOW THEREFORE, in consideration of the mutual covenants and agreements herein set forth, ESSOVI and Four Winds and Splash and Dash agree as follows:

1. ESSOVI and its employees, agents contractors and subcontractors (hereinafter collectively "representatives") shall have the right to enter the Site to conduct the Site Work at reasonable times and in a reasonable manner with reasonable prior notice to Four Winds and Splash and Dash.

2. ESSOVI and its representatives agree that they: a) shall maintain those portions of the Site entered in good condition throughout the duration of the entry; b) shall perform the Site Work in a workmanlike manner and in compliance with all applicable regulations; c) shall not unreasonably interfere with Four Winds and Splash and Dash access to the Site except as may be necessary to conduct the Site Work and shall thereby minimize interruption to Four Winds' and Splash and Dash's

business as much as reasonably possible; and d) shall as soon as practicable at the conclusion of the Site Work, restore the Site, as nearly as may be reasonably possible, to its prior condition; except that steel access plates will be bolted flush with the ground surface over the two designated ground-water extraction wells.

3. All piping installed by ESSOVI in connection with the Site Work shall remain the property and responsibility of ESSOVI.

4. ESSOVI or its representatives shall notify Four Winds and Splash and Dash in advance of entering the Site and provide written notice one week prior to entry upon the site to conduct any intrusive Site Work necessitating the use of equipment to install wells or excavate trenches. Notice will be understood to be complete upon receipt that is to be confirmed delivery by fax or mail to:

Four Winds Shopping Center
Management Offices
Estate Anna's Retreat
Charlotte Amalie, St. Thomas 00802

and

Elchanan I. Dulitz, Esquire
333 Route 46 West
Fairfield, New Jersey 07004

and

Splash and Dash
c/o Khalil Asfour
Route 38
Estate Anna's Retreat
Charlotte Amalie, St. Thomas 00802

ESSOVI or its representative will provide two-day prior verbal or written notification to Four Winds and Splash and Dash in advance of implementing non-intrusive periodic maintenance and/or monitoring activities on the Site.

5. ESSOVI hereby agrees to indemnify and hold harmless Four Winds and Splash and Dash, Inc. from any and all liability for damages to any person or property arising out of or in

connection with the Site Work described herein which is not due to the negligent or willful acts or omissions of the Four Winds Plaza Partnership and Splash and Dash, its tenants, representatives, or others not a party to this agreement.

6. Splash and Dash agrees that it will not hold Four Winds liable for any action arising out of the Site Work conducted by ESSOVI and that by signing this agreement Splash and Dash acknowledges that the work as described under this agreement will not interfere with Splash and Dash's tenancy rights and/or business operations.

7. Four Winds and Splash and Dash shall cooperate with ESSOVI and its representatives by executing such applications for permits and other related documents as are required to permit the lawful performance of the Site Work.

8. Four Winds and Splash and Dash will allow Esso, its subcontractors and representatives free access to those portions of the Site necessitated by the Site Work and will take no steps which prevent the performance or increase the costs of said Site Work.

9. Notifications or correspondence prepared by Four Winds and/or Splash and Dash in accordance with this Agreement should be addressed to:

Esso Standard Oil Company P.O. Box 364269 San Juan, P.R. 00936-4269 Attn: Enrieta Azad, Esq.	and	Forensic Env. Services, Inc. 113 John Robert Thomas Dr. Exton, PA 19341 Attn: Thomas F. Maguire

10. This agreement is to be interpreted in accordance with the laws of the U.S. Virgin Islands.

11. The rights and privileges granted by this Agreement to ESSOVI and its representatives shall commence on the date of execution of the Agreement and shall terminate upon the later of: a) EPA's acknowledgment of ESSOVI's full compliance with the 1998 Unilateral Administrative Order or b) such other orders of EPA or other regulatory agency with jurisdiction over said Site Work or related remediation activities.

12. This Agreement is the complete and exclusive statement of the terms and conditions hereof, notwithstanding any representations or statements to the contrary theretofore made, and any modification to this Agreement shall be in writing, signed by all parties.

ESSO VIRGIN ISLANDS, INC.

BY____________________

FOUR WINDS PLAZA PARTNERSHIP

BY____________________

SPLASH AND DASH, INC.

BY____________________

EXHIBIT A

"SITE WORK"

Installation of EPA's selected remedy for the ESSOVI Tutu service station will entail the drilling of four wells on the Four Winds property proximal to the Splash and Dash car wash. Two of the four wells will be accessed periodically to monitor ground-water quality and obtain ground-water elevations in accordance with EPA's specified compliance monitoring schedule. The remaining two wells will be utilized as ground-water extraction points for the Source Control Program. As such, installation of a two-foot square vault and subsurface piping will be required between the ESSOVI site and these two well locations. These wells will be pumped at an estimated aggregate rate of approximately 2 gallons per minute. Additionally, a subsurface pipe will be required to connect the treatment system on the ESSOVI site with the storm sewer (Turpentine Run) that traverses beneath the Four Winds property. To the extent possible, an existing pipe will be utilized, but in the event this existing pipe is not functional, the installation of a new pipe will be required. The installation of subsurface piping will require trenching across certain portions of the Four Winds property. Subsequent to installation of EPA's specified Source Control Components, in accordance with governmental (EPA/DPNR) requirements, periodic access to the Four Winds property will be required to facilitate monitoring and maintenance at a frequency established by the governing agencies. The above-noted tasks constitute the "Site Work". Specifics of Esso's Source Control Program are more fully set forth in a document titled Remedial Design Investigation Source Control Program, Esso Tutu Service Station, June 1997, a copy of which was forwarded to Four Winds in 1997.

APPENDIX D
Contractor Qualifications

O'Brien Construction

O'Brien CONSTRUCTION COMPANY

POST OFFICE BOX 502037 • ST. THOMAS, U.S. VIRGIN ISLANDS 00805-2037
TEL: (340) 777-7809
FAX: (340) 775-2522

FIRM OVERVIEW

O'Brien Construction Company is a general contractor, incorporated in St. Thomas, V.I. in 1972. We have a bonding capacity of $5 million through Tunick Insurance. We have been involved in every facet of the construction business, from the design and construction of luxury homes - to hotel, condominium and commercial complexes. We have completed over $100 million in projects here in the Virgin Islands over the past 25 years. Many of those projects were with the V. I. Government. Projects include, in addition to the above, municipal water and sewer main utilities, pump stations, sewage lift stations and treatment plants as well as a wide variety of Hurricane Restoration work.

O'Brien Construction has a fully staffed warehouse/compound on two acres with computerized inventory. Forklifts and trucks handle all of the staged construction materials for use at any given project.

O'Brien Construction Company has built up a strong relationship with numerous local contractors and subcontractors, who provide electrical, mechanical, stonework/masonry, etc.

We have a working relationship with Chase Manhattan Bank, the Bank of Nova Scotia and Merrill Lynch.

EDWARD O'BRIEN

EDUCATION:

New York Institute of Technology,
Architectural and Structural Design

Brooklyn Institute of Design and Construction
Structural Engineering

Mechanics Institute of New York
Plumbing, Heating, & Mechanical Engineering

Mr. O'Brien has been a resident of the United States Virgin Islands for the past [illegible] years. He has owned and operated his own construction firm since 1968. He has been involved in every facet of the construction business, from the design and construction of luxury homes, to hotel, condominiums, and commercial complexes. Mr. O'Brien has also completed a number, and a wide variety, of Government projects: municipal water and sewer main utilities, pump stations, sewage lift stations, and treatment plants. He has also completed large Government contracts on schools, the Criminal Justice Complex, Hospital and Housing Authority projects, both on St. Thomas and St. Croix.

Mr. O'Brien has also owned and operated two plumbing wholesale/retail supply houses, one on St. Thomas and one on St. Croix, which he sold in 1988. He has since been involved in real estate development, successfully completing a 174 unit sub-division in St. Thomas, and the first phase of the Orange Grove Condominium project in St. Croix.

GOVERNMENT OF
THE VIRGIN ISLANDS OF THE UNITED STATES

MARCH 30, 19 98

Office of the Custodian, Government Insurance Fund

(DEPARTMENT OF FINANCE)

Certificate of Government Insurance Coverage

I certify that the employer O'BRIEN CONSTRUCTION CO. *has filed with the Custodian of the Government Insurance Fund, the Employer's Report to the Commissioner of Finance and paid the required premium in accordance with the provision of Title 24 Chapter 11, Section 273, of the Virgin Islands Code, and, accordingly is entitled to the rights and benefits of the insurance coverage established by law. The risk of this employer is covered by policy No.* 3058 *for the period from* JANUARY 1, 19 98 TO DECEMBER 31, 19 98

NAME & ADDRESS OF EMPLOYER

O'BRIEN CONSTRUCTION CO.

P.O. BOX 502037

ST. THOMAS, VIRGIN ISLANDS 00805-2037

AUDREY T. SMITH

FOR COMMISSIONER OF FINANCE
CUSTODIAN, GOVERNMENT INSURANCE FUND

CONTROL No. 98- 06444 **LICENSE NO.** 1-09657-98

THE GOVERNMENT OF THE VIRGIN ISLANDS
DEPARTMENT OF LICENSING AND CONSUMER AFFAIRS
LICENSING DIVISION
HEREBY MAKES KNOWN

That, in accordance with the applicable provisions of Title 3 Chapter 16 and Title 27 V.I.C. relating to the licensing of businesses and occupations. and compliance having been made with the provisions of 10 V.I.C. Sec. 41 relating to the Civil Rights Act of the Virgin Islands, the following license is hereby granted.

LICENSEE NAME	OBRIEN PLUMBING CO INC	TYPE OF LICENSE	CONSTRUCTION CONTRACTOR
LICENSEE MAILING ADDRESS	P.O. BOX 502037 STT V.I 00805-2037	TYPE OF LICENSE	
TRADE NAME	OBRIEN CONSTRUCTION CO	TYPE OF LICENSE	
TRADE ADDRESS	4-D CONTANT ST. THOMAS VI	TYPE OF LICENSE	
ESS NO.	16959	SOCIAL SECURITY OR WITHHOLDING TAX IDENTIFICATION NO.	2636

As provided by law, the authorized licensing authority shall have the power to revoke or suspend any license issued hereunder. upon finding, after notice and adequate hearing, that such revocation or suspension is in the public interest; provided. that any persons aggrieved by any such decision of this office shall be entitled to a review of the same by the territorial court upon appeal made within 30 days from the date of the decision; provided. further. that all decisions of this office hereunder shall be final except upon specific findings by the Court that the same was arrived at by fraud or illegal means.

1998

This License is valid from 06/01/98 to 05/31/99 If a renewal is desired, the holder is responsible for making application for the same without any notice from this office. In event of failure to do so it will be understood that the business is without legal authority to continue and will be closed. It is the responsibility of the Licensee to notify the department in writing, when a license is to be cancelled or placed in inactive status.

Issued at
V.I., this 26 98 day of March
A.D., 19
Fee $200.00

Commissioner, Department of Licensing and Consumer Affairs

THIS LICENSE MUST BE PROMINENTLY DISPLAYED AT PLACE OF BUSINESS

CERTIFICATION
Certified to be a true and correct copy
Kenneth A. Lapp
Lieutenant Governor

ARTICLES OF INCORPORATION

OF

O' BRIEN PLUMBING CO., INC.

We , the undersigned , desiring to form a stock corporation pursuant to the provisions of the Code of Laws of the Virgin Islands of the United States of America , do hereby certify as follows :

F I R S T : That the name of the corporation is

O'BRIEN PLUMBING CO., INC.

S E C O N D : That the purposes for which it is to be formed are to do any and all of the things hereinafter set forth to the same extent as natural persons might or could do in any part of the world , namely :

1. To engage in the general plumbing business as general contractor , sub contractor , joint venturer , and to buy , sell , deal in , finance , handle and repair plumbing fixtures , equipment , supplies , at wholesale and / or retail , in the Virgin Islands and elsewhere .

2. To engage in a general merchandising and trading business , and to import , export , buy and sell at wholesale and/or retail , articles , goods and commodities manufactured or produced in any part of the world , and to receive articles , goods , commodities and merchandise on consignment or otherwise , from any foreign country or territory , from Puerto Rico , from the United States or any of its possessions .

3. To buy , sell , develop , lay out , plan , lease , manage , operate , maintain , control , license the use of , publicize , advertise , promote , and generally deal in and with , whether as principal , agent , broker or otherwise , improved and unimproved real and personal property of all kinds .

4. To engage in the manufacture , processing , creation , or production of any articles or commodities , or to engage in any other business that the Board of Directors of the corporation may deem to be necessary or desirable in connection with the operation and activities of the corporation .

5. In general , to carry on any other business in connection with the foregoing , and to have and exercise all the powers conferred by the Code of Laws of the Virgin Islands of the United States , and to do any or all of the things hereinbefore set forth to the same extent as natural persons might or could do , and in any part of the world .

6. The foregoing clauses shall be construed both as objects and powers and , except where otherwise expressed , such objects and powers shall be in no wise limited or restricted by reference to , or inference from , the terms of any other clause in these articles of incorporation , but the objects and powers so specified shall be regarded as independent objects and powers , and it is hereby expressly provided that the foregoing enumeration of specific powers , shall not be held to limit or restrict in any manner the powers of the corporation .

49
50
73

T H I R D : That the capital stock of the corporation shall consist of 1000 shares of common stock at no par value . There shall be no preferred stock .

F OU R T H : That the minimum amount of capital with which the corporation shall commence business shall be $ 1,000.00 .

F I F T H : That the location of the principal office of the corporation in the Virgin Islands is Parcel 39 , Sub Base , St. Thomas, Virgin Islands (P. O. Box: 4123) , and the resident agent is Frederick D. Rosenberg , whose address is The Professional Building , P. O. Box: 1279 , St. Thomas, Virgin Islands .

S I X T H : That the duration of the corporation is to be perpetual .

S E V E N T H : That the by-laws of the corporation shall set the number of directors , which shall not be less than three .

E IG H T H : That the names and places of residence of the persons forming this corporation are as follows :

HELGA WILLIAMS, # 3 Estate Thomas, St. Thomas, Virgin Islands
MARY GRIGG , 148 - 7 Estate Tutu , St. Thomas, Virgin Islands
GAIL SHEFFIELD , # 2 J Estate Hull , St. Thomas, Virgin Islands

N I N T H : That , in furtherance of the general powers conferred by , and subject to the conditions and limitations of the Code of Laws of the Virgin Islands , the Board of Directors of the corporation is expressly authorized :

a. to adopt by-laws for the governance of the corporation , subject to the right of the stockholders to amend or repeal the same;

b. to fix the amounts to be reserved for and as working capital for the corporation or for any other purposes ;

c. to declare dividends out of the surplus profits of the corporation at their discretion ;

d. to mortgage or sell the real or personal property of the corporation ;

e. to select or designate two or more of their number to constitute a committee to exercise the powers of the Board of Directors in the management of the business of the corporation ;

f. to contract in the name of the corporation with individual members of the Board in their individual capacity or as re - presentative of any firm , association or corporation ;

g. to fix and vary the amount of the working capital of the corporation and to determine what , if any , dividends shall be declared and paid ;

h. to authorize and cause to be executed mortgages and liens upon the real and personal property of the corporation ;

i. to set apart out of any of the funds of the corporation available for dividends a reserve or reserves for any proper purpose , or to abolish any such reserve in the manner in which it was created ;

T E N T H : The corporation reserves the right to amend, alter or repeal any provision contained in these articles of incorporation in the manner now or hereafter prescribed by statute, and all rights conferred upon stockholders therein are granted subject to this reservation.

IN WITNESS WHEREOF, we have hereunto subscribed our names this 31 day of May, 1972.

Witnesses :

Helga Williams
HELGA WILLIAMS

Mary Grigg
MARY GRIGG

Gail Sheffield
GAIL SHEFFIELD

TERRITORY OF THE VIRGIN ISLANDS)
) ss.:
DISTRICT OF ST. THOMAS)

On this 31 day of May, 1972, before me, the undersigned officer, personally appeared HELGA WILLIAMS, MARY GRIGG and GAIL SHEFFIELD, to me known or satisfactorily proven to be the persons whose names are subscribed to the within instrument and acknowledged that they executed the same for the uses and purposes therein contained.

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

NOTARY PUBLIC

CERTIFICATION
Certified to be a true and correct copy
Derek M. Hodge
DEREK M. HODGE
Lieutenant Governor

Certificate of Registration of Trade Names

in accordance with Title 11, Chap. 21, V.I. Code

—o—

Know All Men By These Presents

THIS IS TO CERTIFY THAT O'Brien Plumbing Co., Inc.

a corporation, the principal office of which is located at 24D Estate Mafolie

St. Thomas, V.I.

is doing or intends to do business in the Virgin Islands of the United States; that this business is known or is to be known by the designation, name or style of

O'Brien Construction Company;

that said business is located at 24D Estate Mafolie;

and that the kind of business to be transacted under said name is

construction contractor

IN WITNESS WHEREOF, the said O'Brien Plumbing CO., Inc.
Corporation

has to these presents affixed its corporate seal, and caused the same to be subscribed and acknowledged by its President

and Secretary at the city of St. Thomas

in the (district) of V.I. on the 4th day of June, 1993.

O'Brien Plumbing Co., Inc.
Corporation

(Corporate Seal)

Edward O'Brien
President or Vice-President Edward O'Brien

Barbara O'Brien
Secretary or Assistant Secretary Barbara O'Brien

Acknowledgement

} SS:

On this the 09TH day of June, 1993, before me MELVIN W. RODGEN, the undersigned officer, personally appeared Edward O'Brian who acknowledged himself to be the ~~Vice~~ President of O'Brian Plumbing Co. Inc., a corporation, and that he as such Edward O'Brian being authorized so to do, executed the foregoing instrument for the purpose therein contained by signing the name of the corporation by himself as President

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

(SEAL)

Melvin W. Rodgen
Notary Public
MELVIN W. RODGEN

GOVERNMENT OF
THE VIRGIN ISLANDS OF THE UNITED STATES

Charlotte Amalie, St. Thomas, U.S.V.I. 00802

OFFICE OF
THE LIEUTENANT GOVERNOR

KONGENS GADE NO. 18
CHARLOTTE AMALIE
ST. THOMAS, VIRGIN ISLANDS 00802
(809) 774-2991

February 19, 1998

CERTIFICATION OF GOOD STANDING

This is to certify that the corporation known as O'BRIEN PLUMBING, INC. filed Articles of Incorporation in the Office of the Lieutenant Governor on June 2, 1972 that a Certificate of Incorporation was issued by the Lieutenant Governor on June 15, 1972 authorizing the said corporation to conduct business in the Virgin Islands and the corporation is considered to be in good standing.

Lorna F. Webster

Lorna F. Webster (Mrs.)
Director, Division of Corporation
and Trademarks

O'Brien CONSTRUCTION COMPANY

POST OFFICE BOX 502037 • ST. THOMAS, U.S. VIRGIN ISLANDS 00805-2037 TEL: (340) 777-7809
FAX: (340) 775-2522

CONSTRUCTION PROJECTS COMPLETED
IN THE PAST TEN YEARS

Project Name:	Tobago House
Entity authorizing the work:	Edward O'Brien
Contract Amount:	$425,000.00
Scheduled Completion date:	1991
Is the project on schedule?:	Completed

Project Name:	Kentucky Fried Chicken Building
Entity authorizing the work:	Miller Properties
Contract Amount:	$500,000.00
Scheduled Completion date:	1991
Is the project on schedule?:	Completed

Project Name:	Orange Grove Apartments (St. Croix)
Entity authorizing the work:	Kentropics, Inc.
Contract Amount:	$7,100,000.00
Scheduled Completion date:	November 1991
Is the project on schedule?:	Completed

Project Name:	Villa Little St. James
Entity authorizing the work:	Arch Cummins
Contract Amount:	$2,400,000.00
Scheduled Completion date:	1991
Is the project on schedule?:	Completed

Project Name:	Pillsbury Heights/Road Construction Project - subdivision
Entity authorizing the work:	M.A.F.F., Inc.
Contract Amount:	$1,500,000.00
Scheduled Completion date:	1992
Is the project on schedule?:	Completed

Project Name:	Western Auto Building
Entity authorizing the work:	Tutu Park Limited
Contract Amount:	$1,500,000.00
Scheduled Completion date:	December 1994
Is the project on schedule?:	Completed

Project Name:	Chase Bank Building
Entity authorizing the work:	Tutu Park Limited
Contract Amount:	$1,500,000.00
Scheduled Completion date:	June 1995
Is the project on schedule?:	Completed

O'Brien CONSTRUCTION COMPANY

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FAX: (340) 775-2522

CONSTRUCTION PROJECTS COMPLETED IN THE PAST TEN YEARS

Project Name:	Cyril E. King Airport Terminal Building Renovation
Entity authorizing the work:	Virgin Islands Port Authority
Contract Amount:	$3,350,000.00
Scheduled Completion date:	April 15, 1996
Is the project on schedule?:	Completed

Project Name:	FBI Office Space
Entity authorizing the work:	Al Cohen Mall
Contract Amount:	$200,000.00
Scheduled Completion date:	August 30, 1996
Is the project on schedule?:	Completed
Point of Contact:	Al Cohen

Project Name:	Ross Taarneberg
Entity authorizing the work:	Virgin Islands Housing Authority
Contract Amount:	$400,800.00
Scheduled Completion date:	September 30, 1996
Is the project on schedule?:	Completed
Point of Contact:	Clifford Crooke

Project Name:	Charlotte Amalie Apartments
Entity authorizing the work:	Virgin Islands Housing Authority
Contract Amount:	$343,200.00
Scheduled Completion date:	September 30, 1996
Is the project on schedule?:	Completed
Point of Contact:	Clifford Crooke

Project Name:	Port Authority Administration Building
Entity authorizing the work:	Virgin Islands Port Authority
Contract Amount:	$500,000.00
Scheduled Completion date:	October 15, 1996
Is the project on schedule?:	Completed
Point of Contact:	Dale Gregory

Project Name:	Pollyberg Gardens
Entity authorizing the work:	Virgin Islands Housing Authority
Contract Amount:	$1,713,175.00
Scheduled Completion date:	June 1997
Is the project on schedule?:	Completed
Point of Contact:	Llewellyn Phillips

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FAX: (340) 775-2522

CONSTRUCTION PROJECTS COMPLETED IN THE PAST TEN YEARS

Project Name:	Anna's Retreat Community Housing
Entity authorizing the work:	Virgin Islands Housing Authority
Contract Amount:	$1,532,337.00
Scheduled Completion date:	June 1997
Is the project on schedule?:	Completed
Point of Contact:	Llewellyn Phillips

Project Name:	Heritage Hills Condominiums
Entity authorizing the work:	McComb Engineering
Contract Amount:	$1,700,000.00
Scheduled Completion date:	October 8, 1997
Is the project on schedule?:	Completed
Point of Contact:	Mr. William McComb

Project Name:	Marriott's Frenchmen's Reef Hotel
Entity authorizing the work:	Bovis Construction
Contract Amount:	$1,000,000.00
Scheduled Completion date:	October 30, 1997
Is the project on schedule?:	Completed
Point of Contact:	Mr. Mike Cordiner

It should be noted that the Ross, Charlotte, Port Authority, Pollyberg, Anna's Retreat, Heritage Hills and the Frenchman's Reef Projects listed above were all performed simultaneously, with a combined Contract Value of approximately $7.7 Million. All were completed within their completion date.

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TEL: (340) 777-7809
FAX: (340) 775-2522

CURRENT CONSTRUCTION PROJECTS

Project Name:	Airport Signage
Entity authorizing the work:	Virgin Islands Port Authority
Contract Amount:	$160,000.00
Scheduled Completion date:	October 31, 1998
Is the project on schedule?:	Yes
Point of Contact:	Mr. Byron Todman

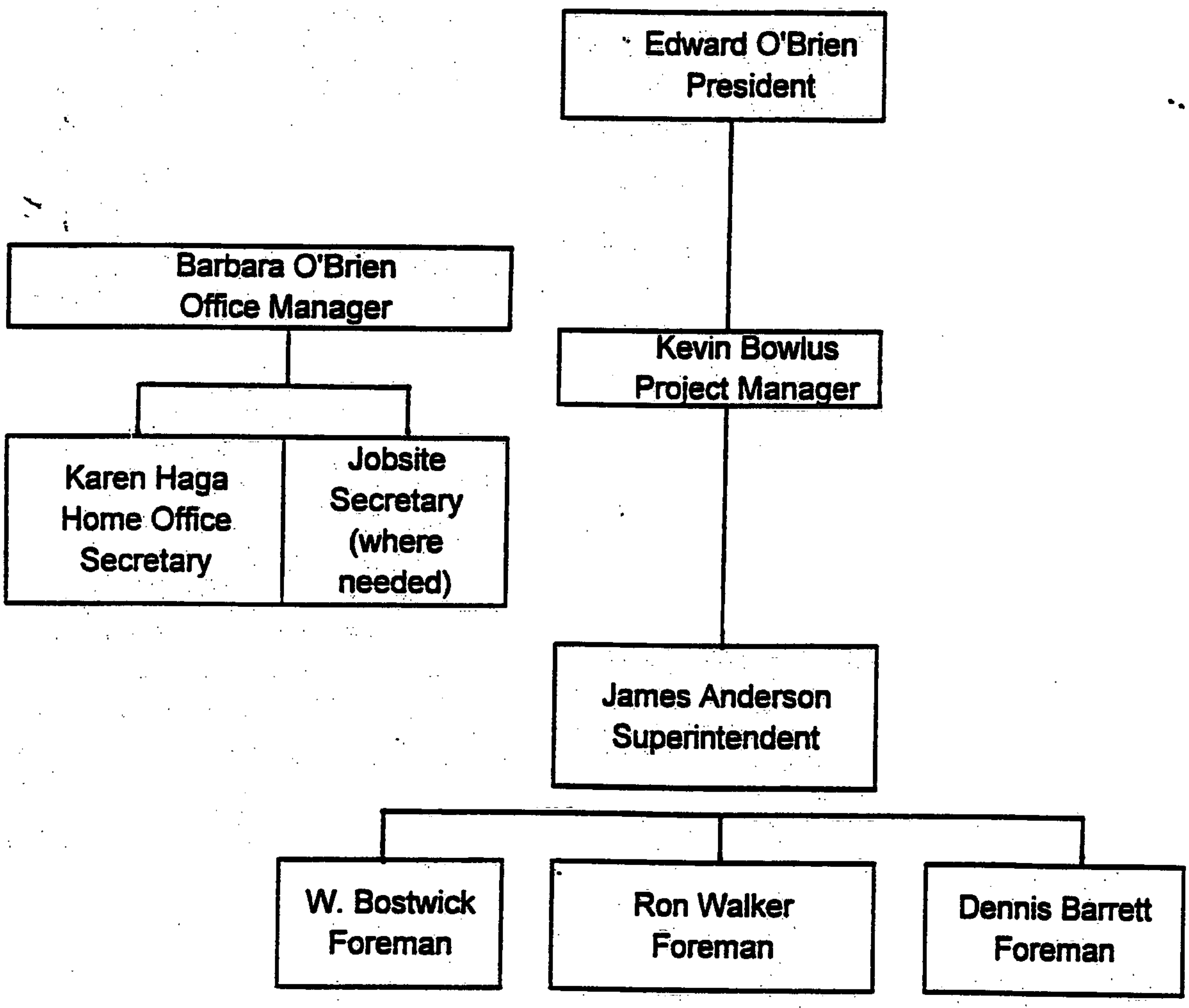
Project Name:	Banco Popular
Entity authorizing the work:	York Hunter
Contract Amount:	$700,000.00
Scheduled Completion date:	December 1, 1998
Is the project on schedule?:	Yes
Point of Contact:	Mr. Martin Bonsignore

Project Name:	The Bunker Renovation
Entity authorizing the work:	F. E. M. A.
Contract Amount:	$89,000.00
Scheduled Completion date:	September, 1998
Is the project on schedule?:	Recently completed
Point of Contact:	Mr. Leonard Gumbs

Project Name:	Kirwan Terrace
Entity authorizing the work:	Virgin Islands Housing Authority
Contract Amount:	$1,212,000.00
Scheduled Completion date:	Six months from Notice to Proceed
Is the project on schedule?:	Not yet begun
Point of Contact:	Mr. Ray Fonseca

O'Brien Construction Company

ORGANIZATIONAL CHART



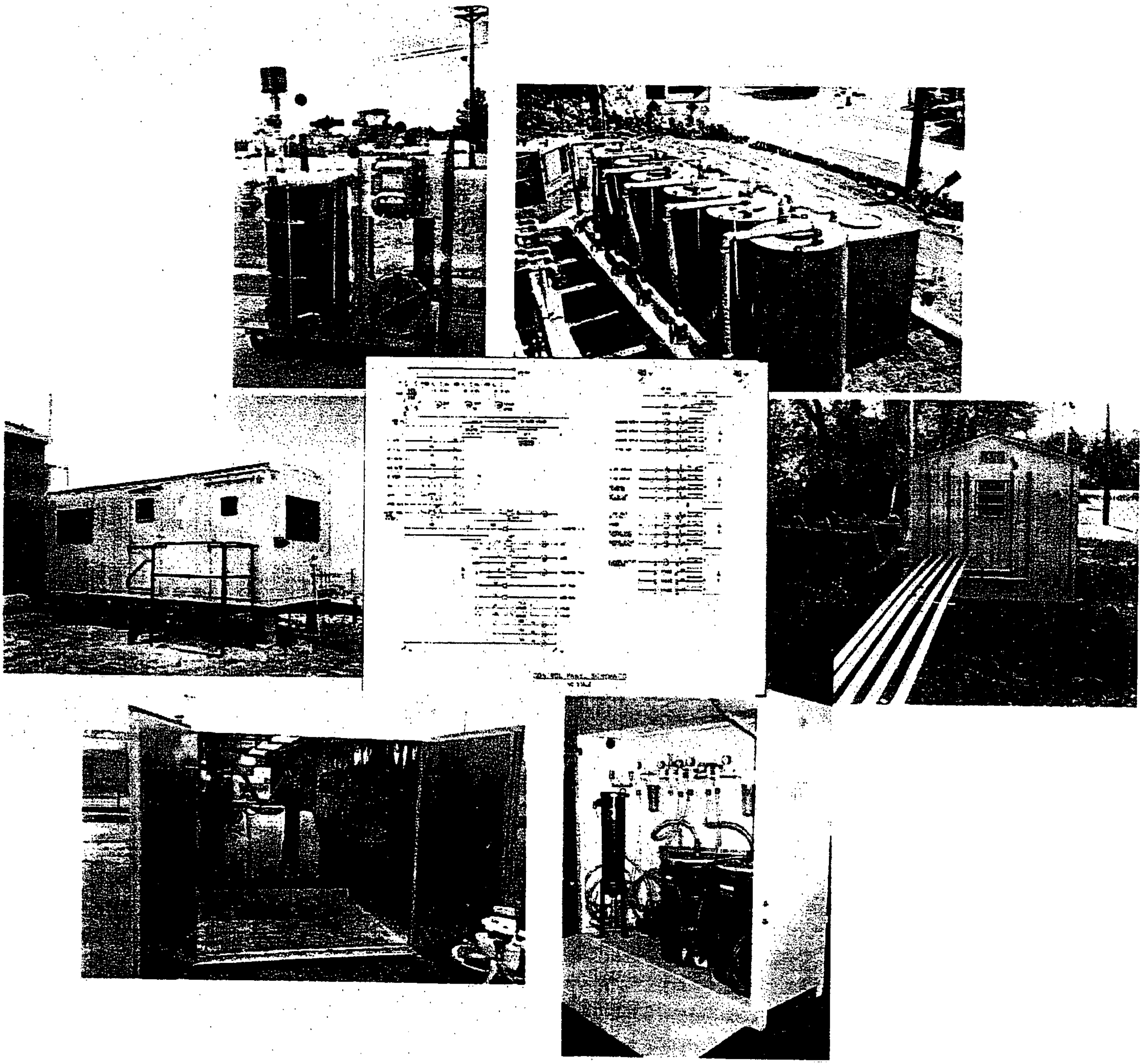
NAME	TITLE	CONSTRUCTION EXPERIENCE	ON-ISLAND EXPERIENCE
Edward O'Brien	President	35 Years	31 Years
Kevin Bowlus	Superintendent	24 Years	12 Years
Ron Walker	Foreman	25 Years	10 Years
James Anderson	Foreman	15 Years	15 Years
Dennis Barrett	Foreman	20 Years	10 Years
Walter Bostwick	Foreman	15 Years	10 Years

Independent Equipment Corporation

IEC

Independent
Equipment
Corporation

Statement of Qualifications



Prepared by:
James Dych, x 459
Independent Equipment Corporation
5 Johnson Drive, PO Box 130
Raritan, NJ 08869
Telephone: 908-526-1001

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APPENDICES

1.0 INTRODUCTION

> *We have built our business on a foundation of long-term clients who expect solutions and have been satisfied with our results.*

Independent Equipment Corporation (IEC) is a provider of engineered products and engineering-focused solutions to environmental and related process engineering problems. We have built our company and business on a foundation of long-term clients who expect solutions and have been satisfied with our results. The solutions offered are generally the simplest and most cost effective. From the beginning of a project, we focus on the client's goals, applying realistic, rational, and proven methods to meet these goals.

Based in Raritan, New Jersey, IEC is a division of Levine·Fricke·Recon (LFR). Our parent company, HW Engineering Group, is a privately-held international engineering and geotechnical services firm with over 1500 employees and worldwide annual revenues of over $300 million.

Since 1975, IEC's formula to serve our customers has started with application engineering and problem solving. We then add experience-based process, control, mechanical, and package design and field-proven components, equipment, fabrication, and service. The result has been the successful design, assembly and installation of complete, integrated systems for industrial air and water treatment and/or soil and groundwater remediation.

Mobile and transportable systems are our specialty. These completely self-contained units can be provided as either skid-mounted, shed-mounted, container-mounted, or trailer-mounted treatment systems.

In addition to providing pre-packaged system components and complete treatment systems, IEC can provide the engineering and/or equipment to modify or retrofit existing systems to meet changing site conditions or improve efficiency. Rental equipment and pilot units are also available from our in-house inventory, or can be custom-designed and assembled to meet site-specific conditions.

IEC has provided its engineering and design services and treatment systems to commercial and industrial clients, environmental engineering/consulting firms, and public sector and governmental facilities on the municipal, county, state, and federal level. We welcome the opportunity to provide these services to help solve your unique problem.

The following pages include information on our range of capabilities, as well as summaries of relevant project experience. Please examine this material and feel free to request further details on any of our capabilities or services which may be of interest to you.

Thank you for considering IEC for your environmental and process engineering needs.

2.0 ENGINEERED SYSTEMS

At IEC, engineering is the difference. Because of the full range of our product line and our engineering expertise, we do not "sell", but rather help you solve your problem in the most economical and technically sound manner. Only then do we solicit your business for an engineered system, if required, which satisfies your specific needs.

We are able to provide process engineering, pilot testing, system design engineering, sampling and analysis, performance testing, installation management, and troubleshooting services when desired.

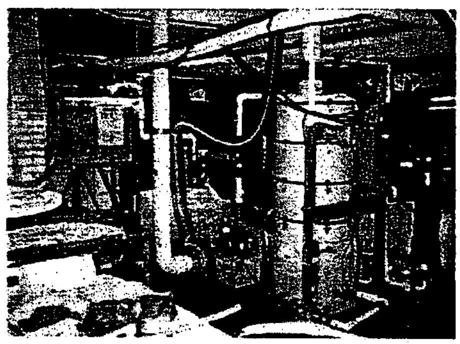
IEC has provided its clients with a variety of pre-assembled and skid-mounted treatment system components, completely packaged skid-mounted treatment systems, transportable shed- and container-mounted treatment systems, and trailer-mounted treatment systems. Transportable systems have been assembled in over-the-road office or van type trailers up to 8.5 feet wide by 8 feet high by 48 feet long. IEC has also supplied shop pre-assembled equipment to be re-assembled at the job site in either the client's existing building or a building specifically designed and erected for the treatment system.

In addition to providing pre-packaged system components and complete treatment systems, IEC has directed modifications to and/or retrofit existing treatment systems with new, different, and/or more efficient components.

Floating gasoline was observed in the basement sump of a federal facility. Within hours after the gasoline was detected, IEC had an interim water and vapor treatment system in place. This interim treatment system prevented discharge of contaminated water and build-up of flammable vapors, allowing IEC time to design and build a permanent treatment system. The permanent treatment system was designed, permitted, built, and installed within four days.

The permanent treatment system included oil/water separation, air sparging, air stripping and activated carbon polishing. Activated carbon is also used to treat the vapor stream driven off by the air sparging and air stripping components of the system. Floating gasoline is recovered and stored in a 500 gallon tank.

IEC's rapid response allowed the building to remain open without interruption. The system recovered 4,300 gallons of free product in its first month of operation, and continues to remove dissolved contaminants with IEC providing operation and maintenance (O&M) assistance.



Treatment system includes: oil/water separator, air sparging, air stripping, and controls.

Liquid phase (left) and vapor phase (right) granular activated carbon (GAC) adsorber vessels

2.1 Water / Wastewater Treatment Systems

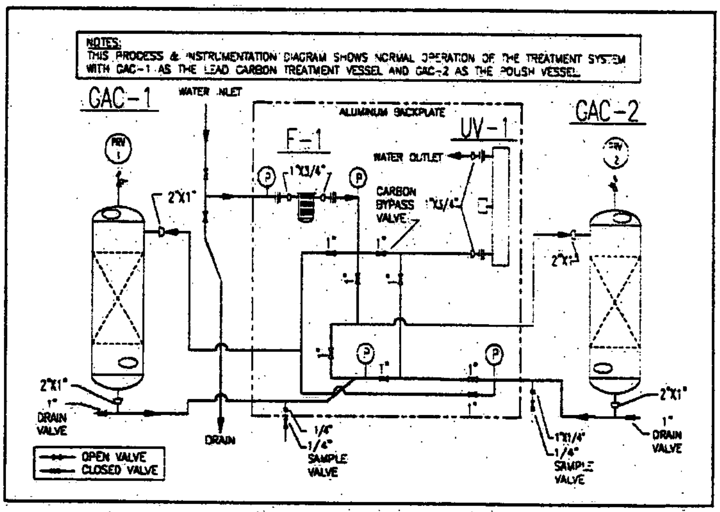
IEC has provided completely packaged water and wastewater treatment systems to accommodate liquid flow rates ranging from 1 to 600 gallons per minute. Depending on site-specific conditions, IEC designs and builds systems consisting of any combination of the following treatment processes.

- Air stripping towers using random or structured packing.
- Aeration systems, agitators, clarifiers, and portable mixers.
- Disposable liquid phase activated carbon units and systems (Note: some applications allow on-site or off-site reactivation of spent carbon or units).
- Cooling towers and closed circuit cooling systems.
- Custom-designed and pre-engineered, packaged water treatment systems for organics and metals.
- Dissolved metals and minerals removal.
- Ion exchange.
- Oil skimmers and oil/water separators.
- Screening, filtration, and de-watering systems for removal of suspended solids.
- Tanks—single/double wall; standard/custom sizes; above/below grade.
- Ultraviolet oxidation.
- Vacuum filters for water and industrial coolants.

When an aluminum extruding facility in New Jersey discovered that its well water was contaminated with chlorinated solvents, IEC was contracted to design, build and install a potable groundwater treatment system.

IEC's system incorporates ultraviolet disinfection, particulate filtration and two-stage carbon adsorption to treat up to 7 gallons per minute of groundwater.

The IEC system allows the facility to safely use its well water as a drinking supply for its employees.



Parallel, dual-bed carbon system allows continuous operation, even when one bed is saturated.

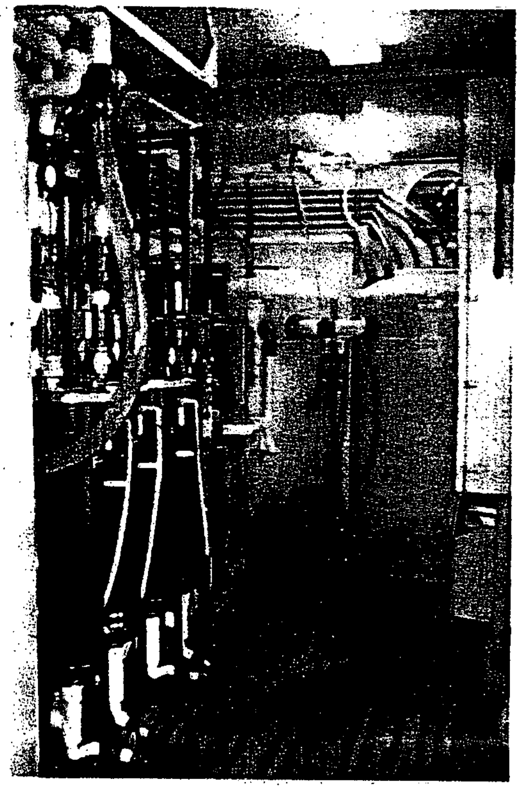
Typical pre-packaged or trailer-mounted system scope-of-supply can include any or all of the following components.

- Inlet Equalization Tank (with oil/water separation optional).
- Low profile and packed-bed air stripper with integral liquid storage volume.
- Liquid and vapor phase granular activated carbon adsorption vessels.

- Feed and transfer pumps.
- Instantaneous, recording, and/or totalizing flow meters.
- System air blower - Regenerative type or pressure blower with in-line duct air heater, as required.
- Controls, motor starters, and instrumentation, including Hand-Off-Auto selector switches and control circuits for both internal and external system components.
- Auto-dialer and telemetry.

IEC was retained by an environmental consultant to provide the design engineering and later to build and install a trailer-mounted groundwater remediation system for use at a highway site in New Jersey.

The system is designed to remove petroleum hydrocarbon and gasoline compounds from groundwater contaminated by leaking underground storage tanks containing gasoline and diesel fuel. Process steps include collection, stabilization, filtration, air stripping, and vapor- and liquid-phase carbon adsorption. To accommodate site-specific constraints, the system includes carbon vessels custom-designed for trailer-to-trailer changeout on site.



Special IEC trailer-mounted system features can include:

- Non-electrical propane fired space heater;
- 12 volt D.C. charger and battery system with thermostat and control circuit logic for D.C. solenoid water drain valves (for automatic drain to protect system against freezing);
- Work lights and utility outlets;
- Heat pumps and exhaust fans;
- System piping and wiring, and
- Separate "non-rated" and Class 1, Group D, Division 2 rated process areas.

Use of an elevated trailer system also permits addition of an optional secondary containment system, if desired.

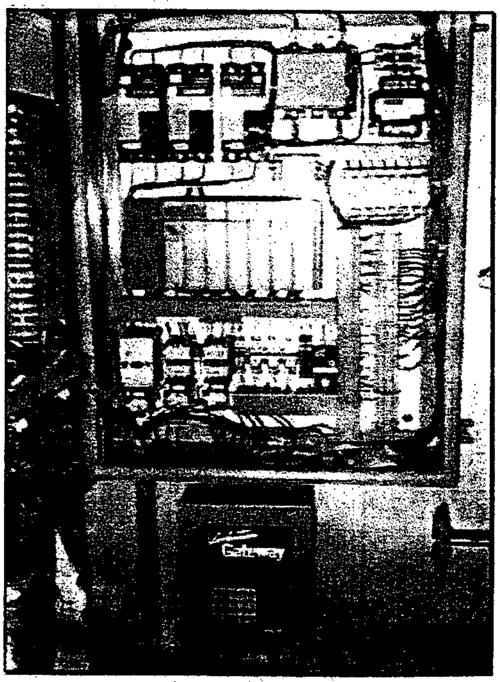
2.2 Soil Treatment Systems

IEC has provided pre-packaged skid-mounted and trailer-mounted soil vapor extraction, air sparging, and combination systems for the treatment of volatile organic contamination in soil. The scope-of-supply for these systems can include any or all of the following components.

- Air sparge blower - rotary vane compressor, positive displacement blower or rotary lobe blower with inlet and in-line filters and accessories.
- Air flow meters - instantaneous or recording.
- Auto-dialer and telemetry.
- Control panel, load center, and electrical equipment.
- Differential pressure switches, and temperature, vacuum, and pressure gauges.
- Explosion proof fan, lighting, and accessories.
- Granular activated carbon canisters - liquid and vapor phase.
- Liquid transfer pump - progressive cavity or gear type.
- Moisture separator with level switches.
- Piping, valves, pressure relief valve, fittings, quick connect fittings, flexible hose, etc.
- Totalizing liquid flow meter.
- Soil vapor extraction blower - regenerative or rotary lobe blower with in-line and inlet filters and accessories.

IEC provided final design and construction of a 120 SCFM Soil Vapor Extraction (SVE) System and 50 SCFM BioVenting system located at a heavy equipment garage. The original system design was modified by IEC to make the system perform more effectively. The basic construction of the system includes three vapor extraction wells, five multi-level monitoring points (three zones per point), pre-cast concrete well manholes, cast-in-place concrete foundations, and a one-story pre-engineered building to house the treatment equipment and controls. System features include a Programmable Logic Controller (PLC) and an Autodialer that can transmit alarm conditions to a remote computer.

The system is designed to remove gasoline components (BTEX) from the soil through three extraction wells. The soil vapor is passed through a moisture separator, the air discharge through an in-line particulate filter, and then through one of two regenerative blowers, connected in parallel. The system valving allows for single operation for each of the blowers. The temperature of the air is increased by the blower(s) as it is discharged, and continues through two 55-gallon vapor phase granular activated carbon (GAC) adsorption canisters connected in series. The temperature increase keeps the moisture in the air above its dew-point, allowing the GAC to remain dry.



Automated system operations and telecommunications allow systems to be operated and monitored remotely, saving on-site operator costs.

2.3 Air Pollution Control Systems

IEC has designed and provided packaged control systems for various commercial and industrial facilities. These have included skid-mounted as well as on-site erected systems for the treatment of volatile organic compounds, particulate matter, and odors.

IEC provided complete design engineering, plans and specifications for an odor control system for an industrial compounder of engineering resins. The client had experienced odor complaints and was under a 30-day order to abate odors or cease operations.

IEC provided complete design services including shop drawings, piping and instrumentation diagrams, and equipment schedules. Final design included an innovative tilted carbon bed, a short-term bypass system with tray-type carbon filters, and all necessary fans, valves and controls. The system was fabricated, installed and successfully brought online with IEC oversight within the required 30-day timeframe.

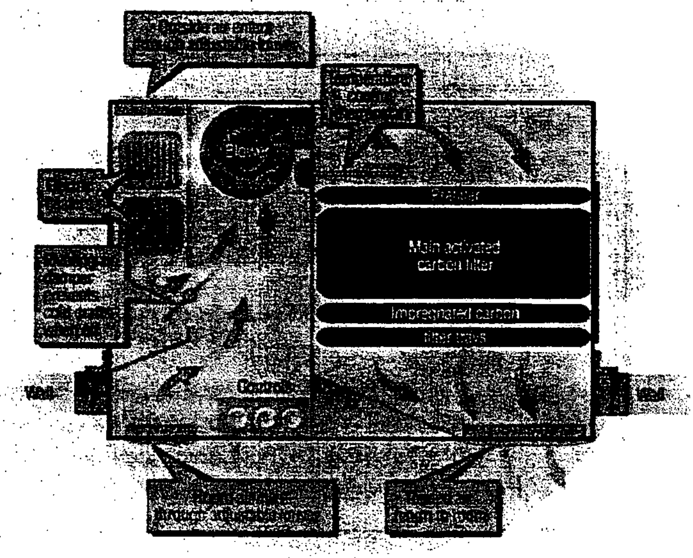
IEC's design of this innovate tilted carbon eases operations & maintainance on the unit.

Our staff has experience in a variety of air pollution control techniques, including chemical and particulate scrubbers, cyclones, fabric filters, electrostatic precipitators, catalytic and thermal vapor phase incinerators, carbon adsorption, and biotreatment. The scope-of-supply for these systems can include any or all of the following components.

- Activated carbon adsorption systems (regenerative and disposable).
- Air strippers and spargers.
- Acid, fume, and special NO_x scrubbers (packed bed and venturi systems).
- Custom polypropylene tanks and ducting.
- Fan/separators and wet dust collectors.
- Plastic fans, hoods and ducts.
- Total room enclosures
- Thermal and catalytic oxidizers.

IEC designed and fabricated window-mounted air purification systems for use at a New Jersey Superfund site. Due to site restrictions, support trailers were close to active work areas. The air systems included filtration and impregnated carbon adsorption to provide makeup air and maintain positive trailer pressure.

Figure 1. Air flow through a typical window-mounted air purification unit



IEC's equipment inventory includes a portable air stripper/scrubber which can be used for pilot studies, either as a stand-alone unit or in combination with other processes for the treatment of difficult to control air streams.

2.4 Process Engineering

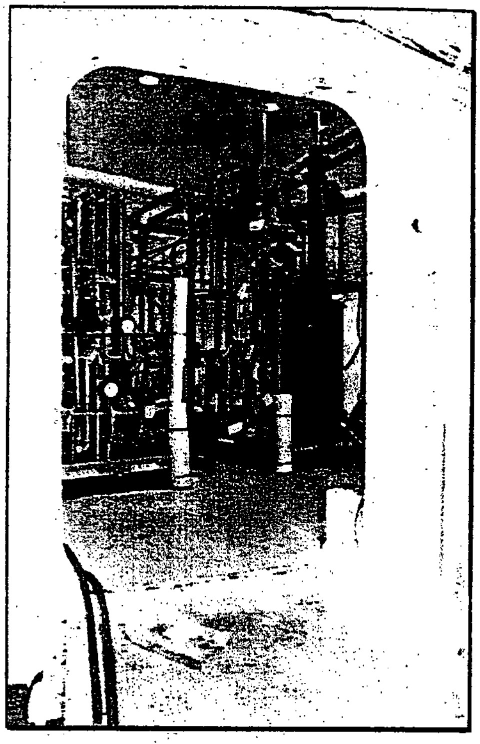
While the vast majority of IEC's applications are environmentally-related, IEC has also performed process engineering, design and supply of packaged and on-site erected systems for other purposes.

Recent projects have included: recycling and product recovery; solvent dispensing; wastewater recovery: and large "bench scale" systems for the treatment and handling of materials ranging from process wastewater to chemical warfare agents. Many of these systems included the use of exotic components, multiple safeguards, and duplicity of mechanical and electrical controls, and were constructed under rigorous quality control standards.

As part of a U.S. Army effort to reduce chemical weapon stockpiles in the United States, IEC designed and built two pilot-scale reactor systems for testing various neutralization reactions for mustard gas and nerve agents. The system consisted of reactors, remote sampling capabilities, temperature control, vapor treatment, remote agent and other reactant feed, and remote capabilities for emergency response. Due to the extreme danger presented by the agent, access to the system was limited, and remote operation was required. IEC's design included motorized valves, PID controllers, SCRs, variable frequency drives, required computer interface electronics, temperature, pressure and level measurement instrumentation. Because operator exposure could not be entirely eliminated, the system was designed ergonomically for operators wearing modified Level A personal protective equipment.

Space limitations in the explosion-proof chamber where the system was to be placed also presented a design challenge. LFR developed a five-skid design that allowed the entire system to fit through the 4' x 6' doorway.

The Army has completed its last round of test runs using IEC's design. They encountered minimal maintenance problems and finished the project with a perfect safety record.



Innovative 5-skid design allowed this system to fit though a 4' x 6' doorway

IEC combined several aspects of its broad design experience to assist a publicly-traded integrated circuits (IC) manufacturer in expanding its operations to a new, larger facility. Four systems (2-propanol dispensing, acetone dispensing, waste solvent collection, and wastewater treatment) were radically redesigned and subsequently installed by IEC in the new building to provide increased throughput, increased automation to provide decreased required operator attention; increased personnel safety; improved process economics. IEC process design, system integration, and project management capabilities have supported the IC manufacturer's effort to push the systems from a "back-of-envelope" concept to installed, operating equipment. Based on the success of these projects, IEC has begun preliminary discussions with the IC manufacturer for installing similar systems in another facility.

3.0 CARBON SERVICES

IEC has designed and supplied various capacity liquid and vapor phase granular activated carbon (GAC) canisters, vessels, and systems. These have included on-site regenerable vapor phase systems, disposable liquid and vapor phase units, and rechargeable liquid and vapor phase systems.

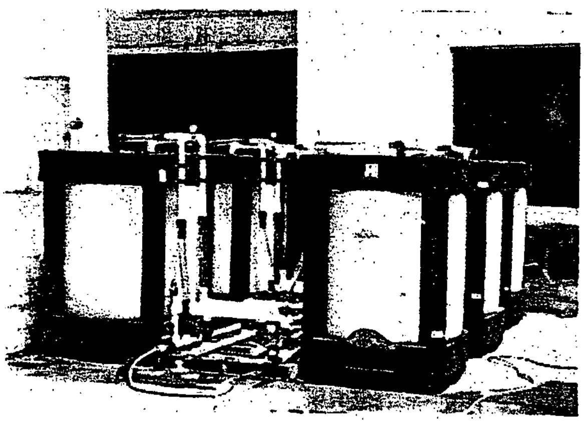
IEC provides liquid and vapor vessels of various sizes for rental or purchase. Custom-built vessels are also available.

IEC can provide bulk quantities of both virgin and regenerated liquid and vapor phase carbon. We can also provide vacuum and re-bedding services for spent adsorber vessels, as well as arranging for "take-back" and "reactivation and return" services of spent carbon classified as either a "non-hazardous" or as a "hazardous" material.

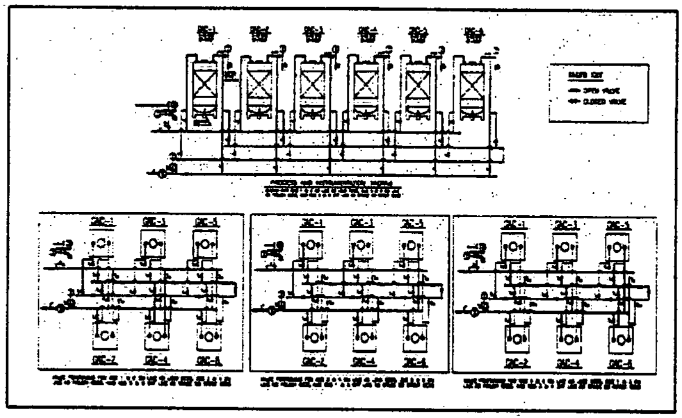
IEC designed and built a groundwater treatment system which was rented by an engineering consultant to remediate fuel contamination. The job site was a mixed industrial/commercial/residential area in New Jersey.

The system includes six liquid phase carbon adsorption units, connected two in parallel with three in series. System piping is skid-mounted between the two rows of adsorbers. Each carbon unit is enclosed in a "frame" so that they can be forklifted individually.

Groundwater is treated at a rate of 10 GPM to a maximum of 30 GPM at a pressure rate of 45 psi.

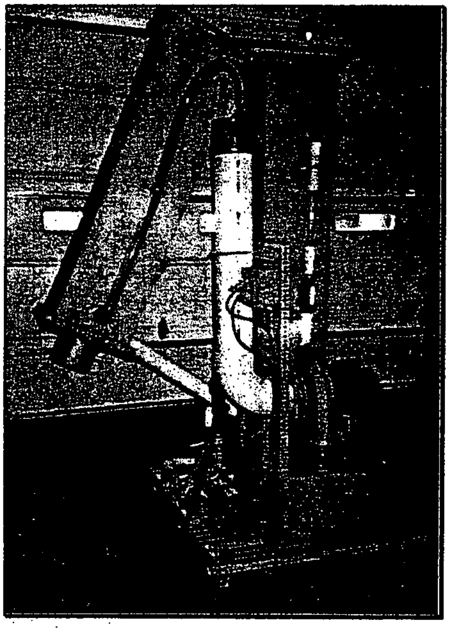


IEC can supply rental units for liquid and vapor phase GAC up to 2,000 lb. capacity.



4.0 PILOT TESTING AND RENTAL SYSTEMS

4.1 Pilot Air Stripper/Scrubber

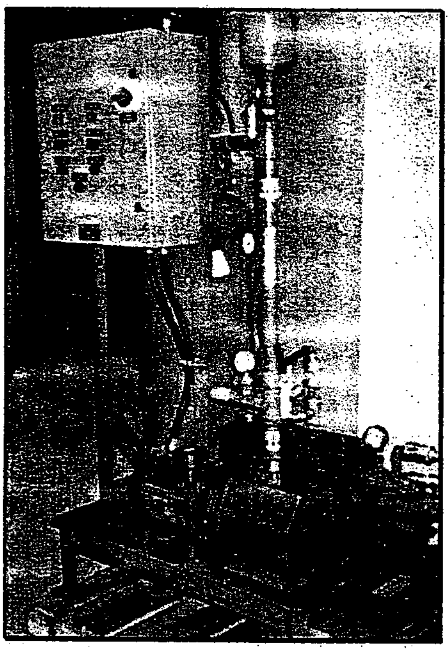


IEC's skid-mounted pilot air stripper/scrubber is a complete packaged system designed to be used at the job site to test treat effluent streams at varying water and air flow rates. In the scrubber mode, the unit is useful for evaluating the relative effectiveness of additives for optimizing control of site-specific air contaminants.

The stainless steel tower contains 14 feet of 12" x 15" structured packing. The stripper/scrubber sump has a capacity of approximately 40 gallons. Process test conditions can be varied by adjusting the flows through the stainless steel pump and aluminum pressure blower by adjusting the flow control valves and dampers and observing the direct read flow meters.

The liquid throughput can be adjusted from 10 to 25 gpm and the air flow rate can be modified from 400 to 600 CFM. Flow rates are dependent on total head, static pressure, and/or pressure drop, and valve and damper settings.

Sampling ports are provided at appropriate locations to determine treatment efficiency.



4.2 Soil Vapor Extraction (SVE) System

IEC's skid-mounted, high-vacuum pump system is designed to be used for soil vapor extraction (SVE) pilot testing under actual conditions at the remediation project site. The SVE system can provide a flow rate of up to 70 ACFM at a vacuum of 27 inches of mercury.

The skid includes an oil-lubricated vane pump with a 5 HP TEFC motor; a 30-gallon moisture separator with liquid level sight gauge, and level switch for pump control; and a ½ HP progressive cavity pump rated for 7 gpm. The system includes flow control and sample valves, quick-connect fittings, temperature and vacuum gauges, and a NEMA 4 control panel.

The 230/3/60 VAC control panel includes run lights, hand-off-auto run switches for the two pumps, a high liquid level light and alarm for the moisture separator, a thermal overload light and alarm, and an alarm reset button.

4.3 Air Sparge (AS) System

IEC's skid-mounted, low- to medium- pressure blower system is designed for air sparge (AS) pilot testing at remediation project sites. The AS system can provide flow rates of 90 to 200 cfm at corresponding pressures of 100 to 10 inches of water column.

The skid includes a regenerative blower (ring compressor) with a 4.5 HP TEFC motor, inlet and inline filters, flow control and sample valves, temperature and pressure gauges, and a NEMA 4 control panel.

The 230/3/60 VAC control panel includes run lights, audible alarm, a hand-off-auto run switch for the blower, and reset, test and silence buttons.

5.0 REPRESENTATIVE CLIENTS

IEC is pleased to provide the following list of current clients utilizing our wide range of engineering services. Additional client names and references can be furnished upon request.

5.1 Consultants

C.A.V. Environmental Services
Capone, Dusz, & Vollmer Environmental
CONsultants
Carroll Engineering Corporation
Conestoga-Rovers & Associates
Converse Consultants East
Dames & Moore
Dan Raviv Associates, Inc
Dresdner Robin Environmental
Management, Inc.
ENSR Remediation And Construction
Foster Wheeler Environmental Corporation
Geraghty & Miller, Inc.
Handex of New Jersey, Inc.
Lahti Engineering, Inc.
Living Technologies, Inc.
Lu Engineers
O'Brien & Gere Engineers. Inc.
OBG Technical Services, Inc.
Prestige Environmental, Inc.
Roy F. Weston, Inc.
S & D Environmental
TAMS Consultants Inc.

5.2 Commercial / Industrial

Airtron Division Of Litton Industries
Alcan Powders & Pigments Co.
Allied Signal Aerospace
Barrier Oil Company
Datascope Corp.
Deep Foods
Dock Resins Corp.
Drobach Equipment Rental
Ethyl-M-Chocolates
IBM Corp.
International Flavors & Fragrances
Lipstick Café
Parker Hannifin
Penetone Corporation
Minalex Corporation
Monoco Oil Co.
Nappi Trucking
New Jersey Electric
Rexam Corp.
Riggins Oil Co.
Rodig Manufacturing
U. S. Aluminum Corp.
U. S. Fuji Electric
Vong Restaurant

5.3 Public / Governmental

Amtrak Mechanical Department
Borough Of Quakertown
GPU Nuclear Corp.
Maine Department Of Environmental
Protection
Middlesex County Parks Department

New Jersey Transit
New Jersey Turnpike Authority
Tennessee Gas Pipeline Co.
Township Of Morris Sewerage Authority
Somerset Raritan Valley Sewerage Authority
U. S. Navy
U. S. Postal Service

5.4 Contractors

A. J. Marques
Cherry Valley Construction
Code Environmental Services, Inc.
Inland Pollution Services, Inc.
Interface Services
Johnson Environmental Services
Laidlaw Environmental Services
Lisbon Contractors
McMorrow Construction
Miller Environmental
Moretrench Environmental Services
Oxford Environmental, Inc.
Retech
Republic Environmental Recycling, Inc.
Rollins Environmental Services (NJ) Inc.
Russel Mechanical, Inc.
Samuel Stothoff Co., Inc.
Sevenson Environmental Services, Inc.
Westinghouse Remediation Services

APPENDIX I

PROJECT ABSTRACTS

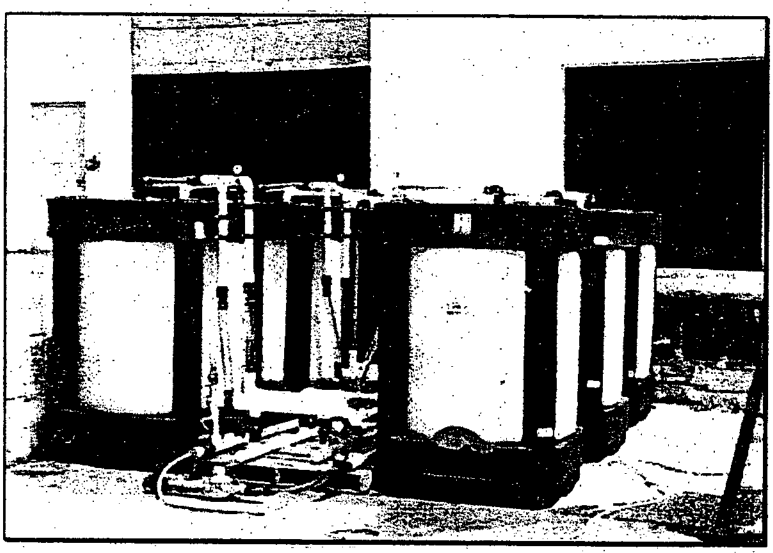
Groundwater Treatment System for Removal of Fuel Contamination

Major Tasks:	• Mobilization and Assembly of Groundwater Treatment System • Carbon Reactivation Services	Project Managers:	Abraham Platt
Performance Dates:	1997	Project Status:	Installation complete. Remediation ongoing.

IEC, the engineered products division of Levine·Fricke·Recon, designed and built a groundwater treatment system which was rented by an engineering consultant to remediate fuel contamination at a site in a mixed industrial/commercial/residential area of New Jersey.

The system includes six plastic 1,000 lb. capacity liquid phase carbon adsorption units, connected two in parallel with three in series. System piping is skid-mounted between the two rows of adsorbers. Groundwater is treated at a rate of 10 GPM to a maximum of 30 GPM at a pressure rate of 45 psi. Each of the six carbon units is enclosed in a "frame" so that each unit can be moved individually by forklift, truck, pallet jack or crane.

IEC mobilized and re-assembled the unit at the client's site, and provides carbon changeout and regeneration services as required.



Skid-Mounted Water Treatment and Remediation System

Major Tasks:	• Design/Build Skid-Mounted Water Treatment System	Project Managers:	Abraham Platt
Performance Dates:	1993 - 300 GPM System 1995 - 600 GPM System	Project Status:	Both systems complete.

In 1993, IEC, the engineered products division of Levine·Fricke·Recon, designed and built a 300 gpm skid-mounted groundwater treatment system for a Pennsylvania-based contractor. The system was designed to remove low levels of volatile organic compounds (VOCs) and sediment from a trench dewatering system at a sewer construction site. IEC also provided engineering and supervision to install all components at the job site.

The original system consisted of a 6,000 gallon coalescing-type oil/water separator (OWS), two 5 hp submersible pumps (located in the clear well of the OWS), three bag filter housings (connected in parallel), and six 2,000 lb. capacity liquid phase granular activated carbon (GAC) adsorber vessels connected three in parallel with two in series.

In 1995, the original system was modified to a 600 gpm flowrate with components leased from IEC. The modifications included changing the OWS use to a collection/sedimentation/transfer tank, replacement of the submersible pumps with a 20 hp TEFC centrifugal transfer pump, and adding nine bag filter housings and six 2,000 lb. capacity liquid phase GAC adsorber vessels. The control panel was also modified and a 20 hp motor starter was added to operate the system.

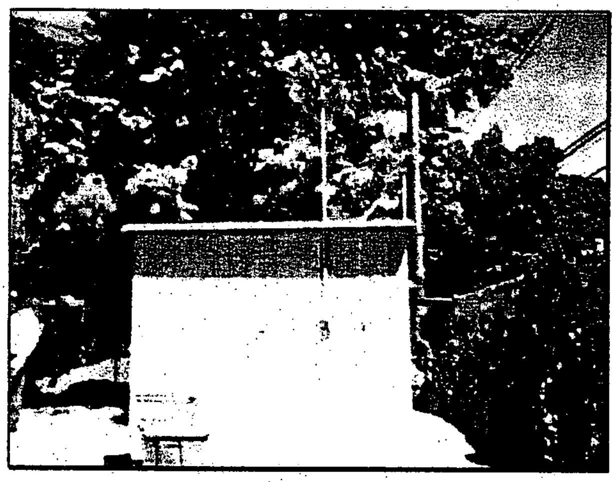
The modified system treated groundwater as follows: the water was drawn from a dewatering trench using the contractors trash pump, to the 6,000 gallon sedimentation tank; water was then pumped through either of two filtering streams consisting of six bag filter housings, connected in parallel. The filtered water was then treated by GAC prior to discharge. The GAC treatment consisted of twelve 2,000 lb. capacity adsorber vessels connected six in parallel with two in series. The piping and instrumentation for this system included bleed and sample valves, flow control and block valves, pressure gauges, differential pressure switches, a pressure release valve, a rupture disk, and a totalizing flow meter.

In both instances, treated water was discharged from the GAC vessels to the publicly-owned treatment works.

Construction and Installation of a Soil Vapor Extraction/BioVenting System

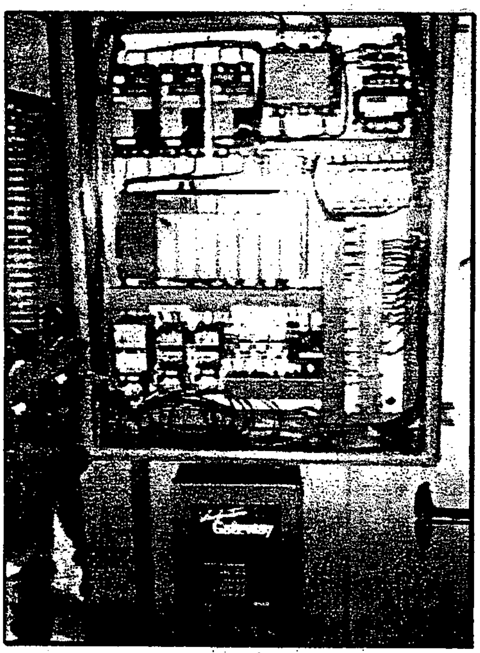
Major Tasks:	• Construction and Installation	Project Managers:	Christopher J. Wojtowicz, EIT
Performance Dates:	1997	Project Status:	System installation complete. Operation in progress.

IEC is the contractor for the final design and construction of a 120 SCFM Soil Vapor Extraction (SVE) system and 50 SCFM BioVenting system located at a New Jersey county facility's heavy equipment garage. The original system design, which was done by another firm, was modified by IEC to make the system perform more effectively.



The basic construction of the system includes three (3) vapor extraction wells, five (5) multi-level monitoring points (3 zones per point), pre-cast concrete well manholes, cast-in-place concrete foundations, and a one-story pre-engineered steel building to house the treatment equipment and controls.

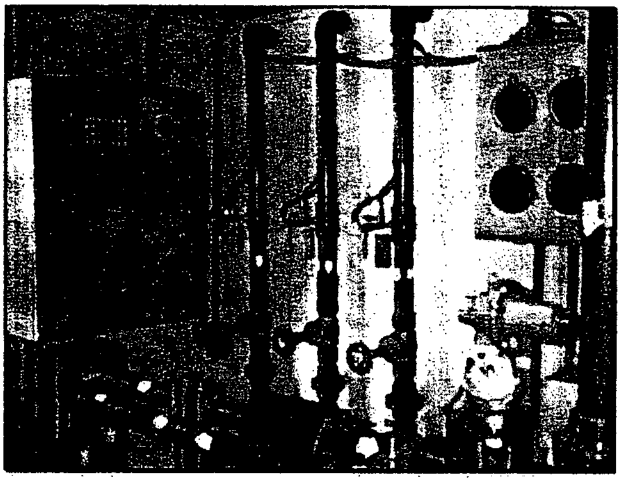
Some of the system features include a Programmable Logic Controller (PLC) and an Autodialer that can transmit any alarm condition(s) to a remote computer.



The SVE System is designed to remove gasoline components (petroleum hydrocarbons, benzene, toluene, ethylbenzene, and total xylenes) from the soil in an existing underground storage tank area. The soil vapor is drawn from three extraction wells installed at the job site with a combined total maximum flow rate of 120 cubic feet per minute (cfm). The soil vapor is passed through a moisture separator. Water collected in the moisture separator is pumped to a water storage tank which has a sight gauge type level indicator. When required, water collected in this tank is removed manually. The drain valve provided near the bottom of the tank can be used to take a water sample for laboratory analysis.

The air discharge from the moisture separator passes through an in-line particulate filter and then through one of two regenerative blowers, connected in parallel. The system valving allows for single operation for each of the blowers. The air temperature is increased on the discharge side of the blower and continues through one 55-gallon size vapor phase granular activated carbon (GAC) adsorption canister. The two canisters are connected in series. A high air pressure switch senses air pressure at the canister's inlet manifold. A sample valve is located on the canister's discharge manifold, prior to the discharge stack.

The GAC adsorbs the volatile gasoline components from the air stream by a mass-transfer process. GAC beds eventually become "spent", and require periodic change out. The system uses carbon canisters in series so that when "breakthrough"—an increase in volatile component concentrations leaving the first stage carbon canisters—occurs in the first or "lead" drums, the second or "polish" drums continue to adsorb the volatile components.



Regular sampling (using the sample valves provided) will determine when breakthrough has taken place. Each carbon bed is self-contained within a DOT-rated and transportable 55-gallon steel drum. When required, spent canisters are removed from the system and replaced with fresh canisters.

Spent canisters are shipped off site to an US EPA RCRA Part "B" approved treatment, storage, and disposal facility for reactivation of spent GAC. Serviced canisters are then returned to the site for future use at the next change out cycle.

Normal operation for the soil vapor extraction system is by automated control with regular operation and maintenance checks by the system operator.

Potable Groundwater Treatment System

Major Tasks:	• Design/Build Groundwater Treatment System	Project Managers:	Abraham Platt
Performance Dates:	1997	Project Status:	Complete

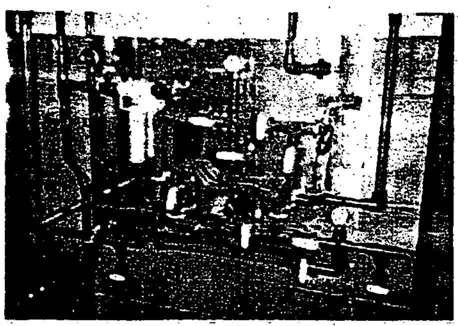
When an aluminum extruding facility in New Jersey discovered that its well water was contaminated with chlorinated solvents, IEC was contracted to design, build and install a potable groundwater treatment system.

IEC designed a system which incorporates ultraviolet disinfection, particulate filtration and carbon adsorption to treat up to 7 gallons per minute of groundwater. Raw water is pumped through a ten-micron particulate filter, and then through two stages of granular activated carbon (GAC), resulting in the removal of approximately 99% of the volatile organic compounds (VOCs) from the groundwater. The ultraviolet disinfection unit destroys bacteria. The two stage carbon filtration ensures that when "breakthrough" occurs in the first stage, the second stage will continue to clean the water until spent carbon can be replaced. Sample valves are located between carbon beds so that the water can be sampled and analyzed to determine when breakthrough occurs.

All piping, valves and gauges are mounted on a vertical, stainless steel rack between the carbon vessels so that controls can be easily accessed by an operator standing on the ground.

The GAC adsorbs volatile chlorinated hydrocarbon compounds from the groundwater by a mass transfer process. The carbon beds absorb these components until an equilibrium condition is reached for adsorption of each organic compound present in the water. The amount of each compound absorbed per pound of carbon will vary from compound to compound. The GAC beds eventually become "spent" and require periodic changeout.

The IEC system allowed the facility to safely use its well water as a drinking supply for its employees.



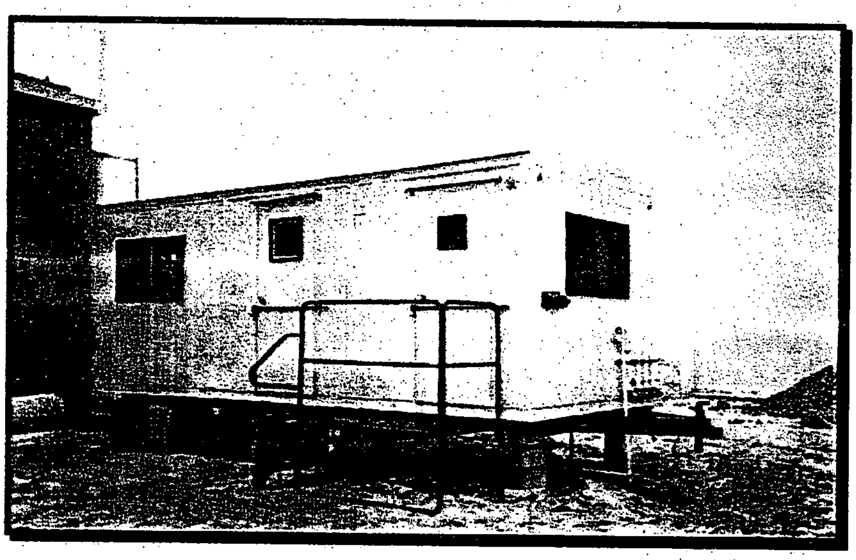
Groundwater Treatment Systems at a U.S. Navy Installation

Major Tasks:	• Groundwater Treatment System • Trailer-Mounted Soil Vapor Extraction and Air Sparge System • Trailer-Mounted Air Sparge System	Project Managers:	Abraham Platt
Performance Dates:	1995-Present	Project Status:	Design, build, & installation complete. Startup of systems in progress.

IEC, the engineered products division of Levine-Fricke-Recon, has provided design/build services for three groundwater treatment systems at a U.S. Navy installation in New Jersey.

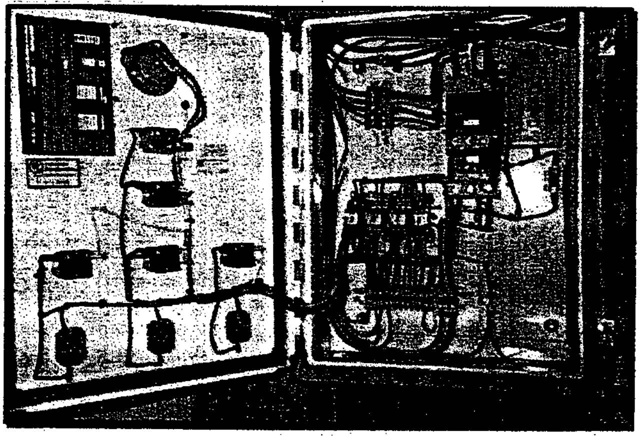
As a subcontractor to the client's consultant, IEC designed and supplied major equipment and auxiliaries for treating flows of up to 250 gpm of groundwater containing organic contaminants including trichloroethylene, 1,2-dichloroethylenes, tetrachloroethylene, xylenes, toluene and ethyl benzene in individual concentrations up to about 35,000 ppbw. IEC supplied a two-stage air stripper, air heater, variable speed blower, two (2) 2000-pound vapor phase granular activated carbon (GAC) adsorber vessels and two (2) 10,000-pound liquid phase GAC adsorber vessels, pumps, flow meters, control instrumentation, O&M manual and startup assistance. Several "clones" of the system were later built at the same facility based on the IEC system design.

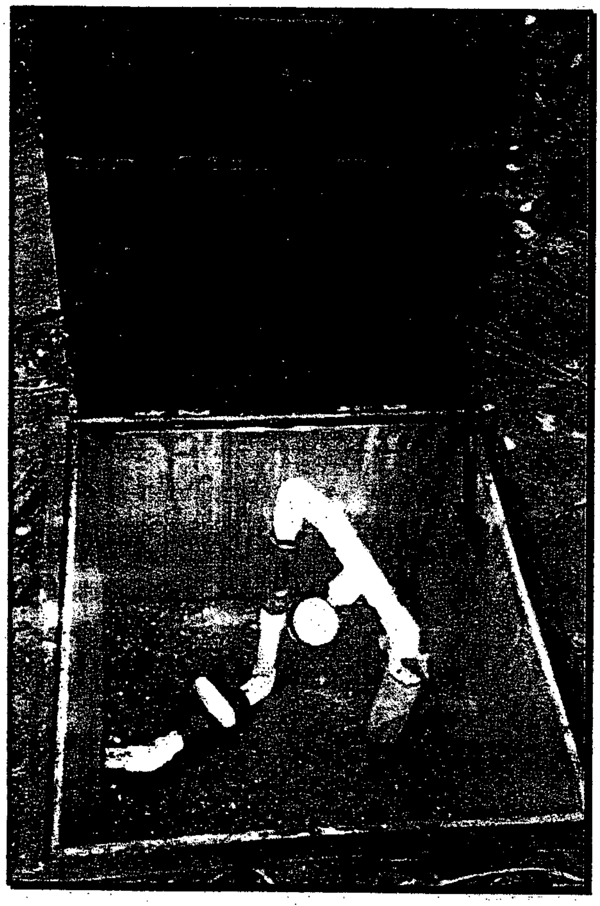
Based on the success of the earlier system, IEC was asked to design and build two additional systems in 1997.



IEC supplied a trailer-mounted soil vapor extraction (SVE) and air sparge (AS) system to remove gasoline components and chlorinated hydrocarbons from the soil in one area of the facility. The system is housed in a two-area trailer, which includes a rated (explosion proof) and a non-rated area. The SVE portion of the treatment trailer rated area draws a maximum of 200 CFM at an applied vacuum of 40 inches of water column from two extraction wells. The extracted air passes through a moisture separator, an in-line particulate filter, a regenerative blower where the air temperature is increased, and then through four 55-gallon GAC adsorber drums connected two in series with two in parallel prior to discharge to atmosphere. The AS portion of the trailer is in the non-rated area and delivers a total of 60 CFM at 20 psi to up to four AS wells. The pressurized air is supplied by a dual stage rotary vane compressor with inlet particulate filters. The systems are operated by automated control, with regular operation and maintenance checks by the system operator.

IEC also provided a trailer-mounted AS system for use at another location at the facility. The system supplies air to the sub-surface soil at a maximum air flow rate of 150 cubic feet per minute at an applied pressure of 15 pounds per square inch. The air is supplied by a positive displacement rotary air blower with an inlet particulate filter, and is distributed through a manifold that branches inside the trailer into two individual headers. Each header provides air flow to six proposed air sparging wells. Air flow to each air sparging well is controlled by a flow control valve and is measured by an in-line flow meter located in each well casement. The system is operated by automated control, with regular operation and maintenance checks by the system operator.





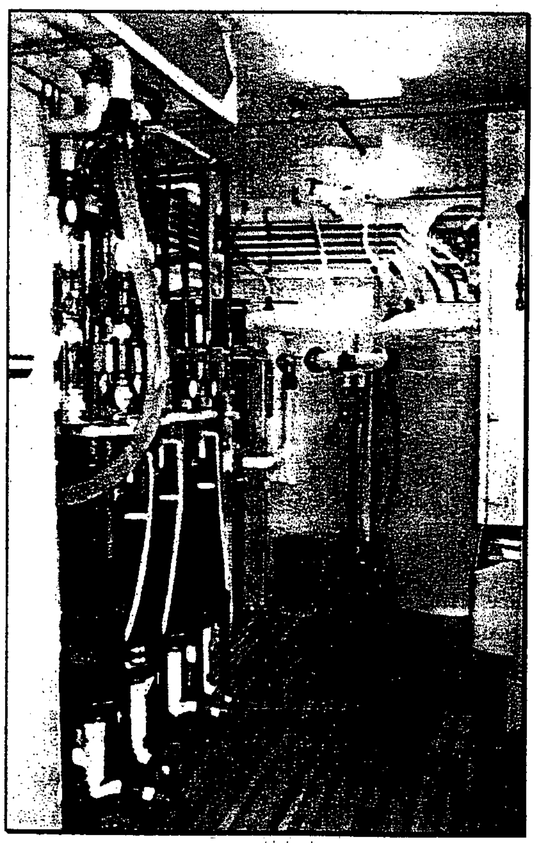
Both trailer-mounted systems can easily be moved and used at different locations throughout the site once cleanup is completed at the initial sites.

Trailer-Mounted Groundwater Remediation System for Removal of Petroleum Hydrocarbons and Gasoline Components

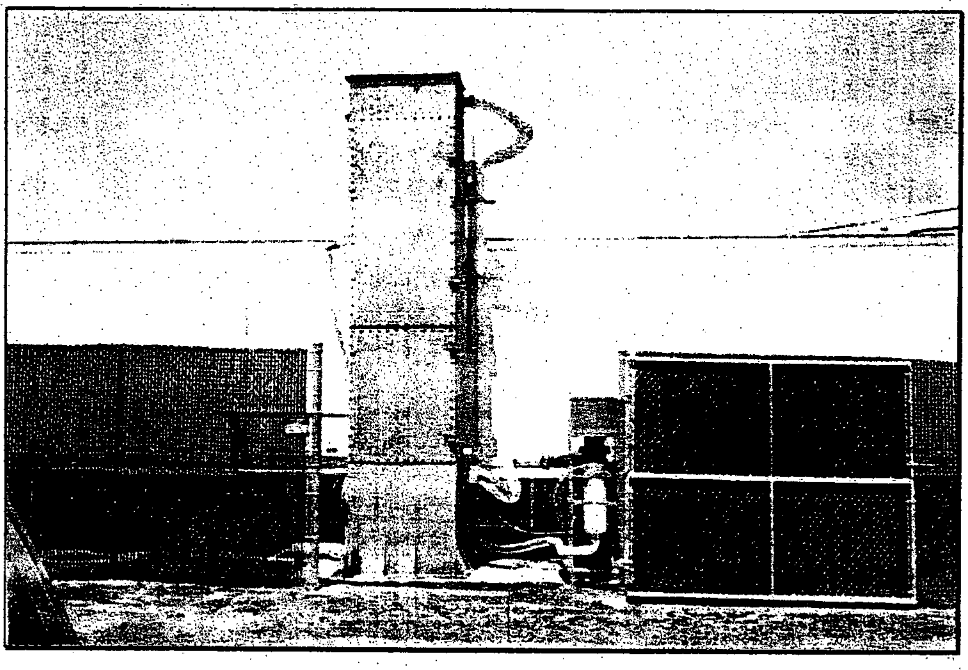
Major Tasks:	• Engineering and design of trailer-mounted groundwater remediation system • Assembly and installation of system • Installation of groundwater wells and pumps • Carbon reactivation services	Project Managers:	Abraham Platt Christopher J. Wojtowicz, EIT
Performance Dates:	1995 - Design phase 1996 - Installation phase 1997 - Carbon Reactivation Services	Project Status:	Design and installation complete. Carbon service ongoing.

IEC, the engineered products division of Levine·Fricke·Recon, was retained by an environmental consultant to provide the design engineering, and later to build and install, a trailer-mounted groundwater remediation system for use at a highway site in New Jersey. The system is designed to remove petroleum hydrocarbon and gasoline compounds from groundwater contaminated by leaking underground storage tanks containing gasoline and diesel fuel.

Water to be treated is drawn, by submersible pumps, from five recovery wells (one pre-existing, and four installed by IEC). The total design flow for the five wells is 35 gallons per minute (gpm). Water is piped to the trailer, where it flows through individual flow meters to a two-stage oil/water separator (OWS) & holding tank. Free product, if present, floats to the top of the OWS tanks and flows by gravity into a 30-gallon recovered product tank when manual decant valves are opened. Normal flow of process water is by gravity overflow from the OWS tank to a steel transfer tank and is pumped through two filter housings to an air stripper tower. The off-gas from the stripper passes through a moisture separator prior to treatment by three 2,000 lb. vapor phase granular activated carbon (GAC) adsorber vessels. The effluent from the stripper sump is pumped through one of two filter housings connected in parallel prior to treatment by two 2,000 liquid phase GAC adsorbers connected in series. Treated water leaving the system is pumped into a re-injection field near the trailer. The treated water then enters the natural groundwater flow, pushing contaminated water toward the recovery wells to repeat the treatment flow cycle.



Water flowing out of the prefilters flows outside the trailer to the top of an air stripper (A/S), which is located outside of and next to the trailer. The A/S is filled with structured packing (mass transfer) material. Water flows down through the packed bed by gravity. Ambient air is drawn through an inlet filter/silencer and is forced upward (i.e. counterflow) through the packed bed. The packing provides a large amount of surface area to allow a thin water layer to form. The water layer interacts with or is aerated by the upward air flow. As the air flows past the water, volatile organic compounds *transfer* (hence, the term "mass transfer") from the water into the air. The water flows down into the stripper sump, where a submersible pump pumps the water back into the trailer into a second set of bag filter housings.



The GAC adsorbs volatile petroleum hydrocarbon and gasoline compounds from liquid and vapor streams by forming a bond between the VOC molecules and adsorption "sites" in the micropore structure of the activated carbon. The carbon beds will continue to adsorb VOCs until an equilibrium condition is reached for the adsorption of each compound. The amount of each compound to be adsorbed per pound of carbon will vary from compound to compound, and will vary by the concentration of a given compound in the liquid or vapor stream.

The GAC beds will eventually become "spent" and will require periodic change out. A bed becomes spent when "break-through" occurs. Breakthrough is measured by an increase in VOC concentrations leaving the first stage (i.e. lead) GAC adsorber vessel. Regular sampling (using the sample valves provided) will be required to determine when break-through has taken place on the lead <u>liquid</u> phase GAC vessel. The solid state GC will provide data on break-through in the <u>vapor</u> phase GAC vessels. One spare each of a liquid and vapor phase GAC adsorber vessel are located in the storage end of the trailer.

This remediation system uses carbon vessels in series so that when break-through occurs in the first or "lead" vessel, the second or third "polish" vessels continue to adsorb the volatile organic components. When required, the spent vessels are removed from the system. The previous polish bed (which is partially spent) is reconnected using flexible hoses to become the new lead bed. Fresh vessels are then connected as the new polish vessels.

Spent vessels are shipped off site to an US EPA RCRA Part "B" approved treatment, storage, and disposal facility for reactivation of the spent GAC. Serviced vessels are then returned to the site for future use at the next change out cycle.

Shed-Mounted Soil Vapor Extraction System

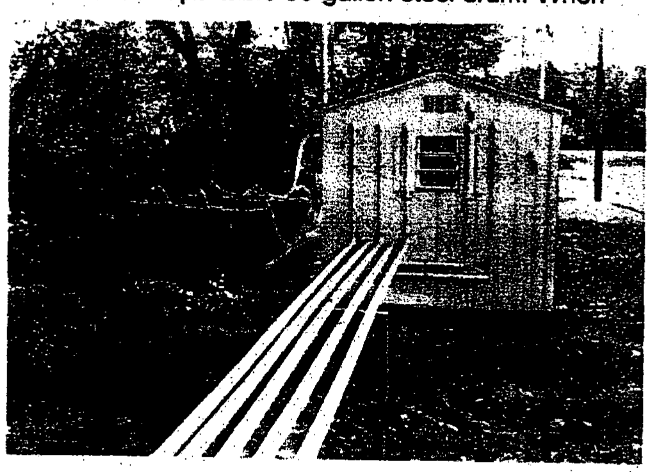
Major Tasks:	• Design/Build Soil Vapor Extraction System • Carbon Reactivation Services	Project Managers:	Abraham Platt Paul R. Fischer, EIT
Performance Dates:	1996	Project Status:	System installation complete. In operation by owner.

IEC, the engineered products division of Levine·Fricke·Recon, designed and built a shed-mounted soil vapor extraction (SVE) system to remove chlorinated hydrocarbons from the soil in a former above-ground storage tank area at a New Jersey manufacturing facility.

The soil vapor is drawn from several extraction wells at a combined total maximum flow rate of 300 cubic feet per minute (cfm) at an applied vacuum of 50 inches of water column. The soil vapor is passed through a moisture separator. Water collected in the moisture separator is pumped to two (2) water storage tanks. These tanks are connected and have a common sight gauge type level indicator. When required, water collected in these tanks can be removed manually. A drain valve provided near the bottom of the tanks can be used to take a water sample for laboratory analysis.

The air out of the moisture separator passes through an in-line particulate filter and then to a regenerative blower, where its temperature is increased, and continues through six 55-gallon size vapor phase granular activated carbon (GAC) adsorption canisters. The canisters are connected three in parallel with two in series. Sample valves are located between stages. A low air pressure switch senses air pressure at the base of the stack to insure proper air hose connections and system air flow.

The GAC adsorbs volatile chlorinated hydrocarbon components from the air stream by a mass-transfer process. GAC beds eventually become "spent", and require periodic change-out. The system uses carbon canisters in series so that when "breakthrough"—an increase in volatile component concentrations leaving the first stage carbon canisters—occurs in the first or "lead" drums, the second or "polish" drums continue to adsorb the volatile components. Regular sampling (using the sample valves provided) will determine when breakthrough has taken place. Each carbon bed is self-contained within a DOT-rated and transportable 55-gallon steel drum. When required, spent canisters are removed from the system and replaced with fresh canisters.



Spent canisters are shipped off site to an US EPA RCRA Part "B" approved treatment, storage, and disposal facility for reactivation of spent GAC. Serviced canisters are then returned to the site for future use at the next change out cycle.

Normal operation for the soil vapor extraction system is by automated control with regular operation and maintenance checks by the system operator.

Multiple System Design, Installation and Start-up for an Integrated Circuits Manufacturer, New Jersey

Major Tasks:	• System Conceptualization • Design Package Development • Procurement, Installation & Start-up • O & M, Detailed Operator SOP's, and Safety Documents	Project Managers:	Joanne J. Scully, PE, CIH Paul R.Fischer, EIT
Performance Dates:	1996-1997	Project Status:	Packaging/Installation Ongoing

IEC, the engineered products division of Levine·Fricke·Recon, combined several aspects of its broad design experience to assist a publicly-traded integrated circuits (IC) manufacturer in expanding its operations to a new, larger facility. Four systems (2-propanol dispensing, acetone dispensing, waste solvent collection, and wastewater treatment) were radically redesigned and subsequently installed by IEC in the new building to provide:

- Increased throughput
- Increased automation to provide decreased required operator attention
- Increased personnel safety
- Improved process economics

IEC's process design, system integration, and project management capabilities have supported the IC manufacturer's effort to push the systems from a "back-of-envelope" concept to installed, operating equipment.

The 2-propanol and acetone dispensing systems allow clean-room technicians to have solvent on tap, where it is needed. Solvent carboy handling is eliminated along with the production inefficiencies and safety hazards they present. These systems feature automatic dispense tank switching, automatic filter selection, automatic venting (including fail-safe vent-valve positioning), and hazard area electrical isolation.

The waste solvent collection system captures used solvents from various sources in the new building. The solvents are segregated by chemical make-up and stored to be reclaimed on-site. When enough solvent has accumulated, an operator dispenses the waste solvent to an appropriate container via air pumps and load cells provided with the system. The load cell is monitored by a PLC to prevent overfilling of the container.

The wastewater system removes solid particles of gallium arsenide. The system uses various settling and filtration steps before discharging the water. The settling tank-bottoms are drummed for further settling, then decanted to the head of the system. The drums are then moved to a dryer, where the gallium arsenide is dried to a paste-like consistency.

Based on the success of these projects, IEC has begun preliminary discussions with the IC manufacturer for installing similar systems in another facility.

Design and Assembly of Trailer-Mounted Groundwater Treatment System

Major Tasks:	• Design/Build Groundwater Treatment System • Carbon Reactivation Services	Project Managers:	Abraham Platt
Performance Dates:	1996	Project Status:	Complete

IEC, the engineered products division of Levine·Fricke·Recon, designed and built a trailer-mounted groundwater treatment system for a remediation contractor to remove gasoline (BTEX) and chlorinated hydrocarbon compounds from groundwater at various sites. The system is contained in a 48' x 102" van-type trailer.

Groundwater is drawn into a 500 gallon equalization tank, and pumped through a bag filter housing and then to a plastic low-profile air stripper at a maximum rate of 22 GPM. The water flow is measured by an instantaneous flow meter prior to the stripper. The air stripper is a tray type stripper containing three trays. Ambient air from the trailer is aerated through the water to remove the volatile components from the groundwater stream. The treated water from the stripper is pumped through a sand filter, followed by four liquid phase granular activated carbon (GAC) adsorption vessels. The GAC vessels are connected two in parallel with two in series. Sampling valves are strategically placed so that water can be obtained anywhere in the treatment system for laboratory analysis to determine the effectiveness of the treatment system or of an individual process step.

Air exiting the stripper passes through a regenerative blower, where its temperature is increased, and continues through four 55-gallon sized vapor phase GAC adsorption canisters connected two in series with two in parallel. Sample valves are located prior to and between stages similar to the liquid phase portion of the system noted above.

The liquid and vapor phase GAC adsorbs volatile hydrocarbon components from the treatment stream by a mass transfer process.

The GAC beds will eventually become "spent" and will require periodic change out. A bed becomes spent when "breakthrough" occurs. Breakthrough is measured by an increase in volatile component concentrations leaving the first stage carbon vessel(s). Regular sampling (using the sample valves provided) will be required to determine when breakthrough has taken place.

The spent GAC is removed for transportation for offsite disposal via thermal regeneration, and replenished with fresh GAC or GAC adsorber drums.

Skid-Mounted Vapor Phase GAC System

Major Tasks:	• Design/Build Skid-Mounted Vapor Phase GAC System	Project Managers:	Abraham Platt
Performance Dates:	1996	Project Status:	Complete

IEC, the engineered products division of Levine·Fricke·Recon designed and built two skid-mounted vapor phase GAC systems for the removal of volatile organic compounds (VOCs) in air. The systems were rented by a remediation contractor for use at a Pennsylvania Superfund site.

The two systems include one rated for 6,000 CFM with 10,000 pounds of vapor phase granular activated carbon (GAC) and the other rated for 350 CFM with 1,000 pounds of vapor phase GAC. The air treated by these GAC adsorber vessels is drawn from the interior of a building being renovated. For the 6,000 CFM system, the air is drawn through a large roll-off type GAC adsorber vessel by an induced draft blower with a 25 HP motor. For the 350 CFM system, the air is drawn through a rectangular, 550 gallon capacity, adsorber vessel by an induced draft fan with a 5 HP motor.

The filtered air from the blower on each system is discharged vertically, at approximately eight feet above grade, through one duct on the large system and another on the small system. The connections to the GAC vessels are made with flexible PVC hose.

The 6,000 CFM system was centrally located in the building to address ventilation of the entire area, while the more portable 350 CFM system was used to address local ventilation.

Skid-Mounted pH Neutralization System at an Electronics Manufacturing Facility

Major Tasks:	• Design/Build Skid-Mounted Components for pH Neutralization System	Project Managers:	Abraham Platt
Performance Dates:	1995	Project Status:	Complete

IEC, the engineered products division of Levine-Fricke-Recon, designed and built a fully transportable, skid-mounted unit for a pH neutralization system at an electronics manufacturing facility operated in New Jersey by an aerospace manufacturer.

IEC's unit was connected to equipment and controls already at the site to make up a pH neutralization system, designed to neutralize influent to a 1,500 gallon storage tank. In addition to the storage tank, IEC provided one 1,500 gallon mixing tank, one 300 gallon acid storage tank, an acid feed pump, a mixer, and two discharge pumps, as well as all required piping and valves. Acid for neutralization purposes is stored in the 300 gallon polyethylene tank, and fed to the mixing tank by an electronic metering pump.

The mixing tank is supplied with an electric mixer fitted with propellers. The tank is designed and fabricated with a 300-gallon still-well for level instrumentation and four internal baffles to assist in the mixing process. The tank is fitted with a standard 16" manway, a flanged coupling for the mixer, two inspection openings, and full NPT couplings for process water inlet, treated water outlet, vent, overflow, drain, acid feed and for the pH probe.

The acid feed tank is fitted with a standard 16" manway, full NPT couplings for acid inlet and outlet, clean water inlet, overflow, drain, vent and the level probe.

The treated water outlet of the mixing tank is connected to two discharge pumps which are piped in parallel so that either or both pumps can be used. The pumps are piped with isolation/control valves, check valves and unions on both sides for easy pump maintenance. A common outlet is provided for the owner's connection to further treatment or discharge.

Skid-Mounted Decon Water Treatment System for Removal of PCBs and VOCs

Major Tasks:	• Design/Build Skid-Mounted Water Treatment System	Project Managers:	Abraham Platt
Performance Dates:	1997	Project Status:	Complete

IEC, the engineered products division of Levine·Fricke·Recon, was retained by a remediation contractor to design and build a skid-mounted water treatment system. The system was designed to remove low levels (ppb to low ppm range) of polychlorinated biphenyls (PCBs) and other trace VOCs from water used to decontaminate (decon) the contractor's equipment being used at a New Jersey job site owned by a surface coating firm.

Normal operation for the decon water treatment system is by manual operator control as specified by the owner/operator. Contaminated decon water is delivered to the system via centrifugal transfer pump which draws water from the accumulation tank or as directed by the operator. Water enters the system at a maximum flow-rate of ten to twelve gallons per minute (GPM). The flow-rate can be adjusted at the discharge of the transfer pump by using the flow control valve.

Water is delivered to the first bag filter housing which contains a 100 micron filter bag. Water continues on to the second bag filter housing which contains a 50 micron filter bag, a third bag filter housing which contains a 25 micron filter bag, and a fourth bag filter housing which contains a 5 micron filter bag. Ball valves are provided on the outlet of each of the bag filter housing to allow the operator to adjust the maximum system flow rate and to switch filter housings when the pressure drop across that housing gets too high.

The filtered water then passes through the liquid-phase granular activated carbon (GAC) bed to remove the contaminants dissolved in the liquid phase. The GAC bed is connected in series to allow the operator to sample between the filter housings and the GAC bed.

A pressure relief valve (PRV) is located before the inlet to the GAC bed to maintain the inlet pressure to the 55-gallon GAC canister at or below the 12 psig maximum pressure rating. Any system inlet pressure in excess of 12 psig is relieved by diverting part of the water flow through the PRV back to the accumulation tank.

Vent and sample valves throughout the system allow for venting air from the water lines during start-up. These valves also allow water samples to be taken at the inlet to the first filter housing, between the filter housings, and after the last filter housing and priors to the GAC bed, and at the outlet of the GAC bed.

Pressure gauges located throughout the system allow the operator to determine pressure drops across all system filters and GAC beds.

Design Upgrade for Water Treatment System at Truck Washing Facility

Major Tasks:	• Engineering/Design Services • Carbon Reactivation Services	Project Managers:	Abraham Platt
Performance Dates:	1995	Project Status:	Complete

IEC, the engineered products division of Levine·Fricke·Recon, provided engineering and design services for an upgrade of a water treatment system treating wash water at a truck washing facility in New Jersey. The system was designed to remove petroleum hydrocarbon compounds and other volatile and semi-volatile organic compounds from the wastewater. The treatment system has two (2) separate treatment streams. The first collects free product from the surface of the water in the center section of a clarifier & sedimentation tank using an adjustable floating oil skimmer with a maximum collection rate of 44 gpm. Free product is pumped to a 300-gallon vertical oil/water separator (OWS) using an air-operated diaphragm pump. Recovered light non-aqueous products form a layer at the top of the OWS and remain there until removed by gravity through an oil decant valve. The recovered product is directed to drums or a product recovery tank by the operator. Water flows out of the OWS by gravity back to the center section of the clarifier & sedimentation tank.

The second treatment stream (the "adsorption" section) draws water from the existing clarifier & sedimentation tank at a maximum flow rate of 10 gallons per minute (gpm). Water is removed from the upper layer of the tank by a submersible transfer pump. The water is pumped through a bag filter housing which removes particulates greater than 10 micron in size.

The water exiting the filter housing passes through two 55-gallon liquid phase granular activated carbon (GAC) adsorption vessels to remove the volatile and semi-volatile organic components from the filtered washwater stream. The vessels are connected in series. Sample valves and pressure gauges are located between stages. The carbon beds will adsorb compounds with an affinity for adsorption on GAC until an equilibrium condition is reached for adsorption of each compound. The weight of each compound to be adsorbed per pound of carbon will vary by compound and concentrations of a given compound in the washwater stream.

The treated water then flows through a totalizing flow meter and a flow control valve prior to discharge. From this point, water flows by gravity to the POTW connection. A flooded sampling valve is provided in the gravity flow section of the discharge piping.

The GAC beds require periodic change out when they become "spent". A bed becomes spent when "breakthrough" occurs. Breakthrough is measured by an increase in organic component concentrations leaving the lead carbon canister. Regular sampling (using the sample valves provided) will be required to determine when breakthrough has taken place.

This system uses carbon canisters in series so that when breakthrough occurs in the first or "lead" vessel, the second or "polish" drum continues to adsorb the organic components. Each carbon bed is self-contained within a DOT-rated and transportable 55-gallon steel drum.